



12657/B

N. V. H.

18/6

J. Davis.

Leine Abbas
Dorset.

11- 21. a 10669

A

M A N U A L

O F

C H E M I S T R Y,

OR A BRIEF ACCOUNT OF THE

OPERATIONS OF CHEMISTRY,

AND THEIR PRODUCTS.

TRANSLATED FROM THE FRENCH OF

M. B E A U M E,

DEMONSTRATOR IN CHEMISTRY AT PARIS, AND MEMBER
OF THE ROYAL ACADEMY OF SCIENCES.

THE SECOND EDITION CORRECTED,

WITH ADDITIONS.

WARRINGTON,

PRINTED BY W. EYRES, FOR J. JOHNSON, NO. 72,
ST. PAUL'S CHURCH-YARD, LONDON.

MDCCLXXXVI.



P R E F A C E

TO THIS EDITION OF THE

T R A N S L A T I O N.

THIS Translation was undertaken principally for the purpose of furnishing some Gentlemen to whom I was giving a course of lectures in Chemistry, with a concise work, which might serve as a reference for all the most important facts relative to this useful science. The author's professed design is to give a brief recapitulation for the use of those who have passed through a course of regular instruction; and at the

same time to provide a sort of elementary work for those who mean only to take a general and cursory view of the subject. His MANUAL, therefore, consists of a short *rationale* of all the principal operations in Chemistry, introduced by so much of the theory of the science, and of the chemical history of bodies, as may render it intelligible to those who have not enjoyed the benefit of previous information. Thus it contains a large store of knowledge in a very small compass; and may be perused with great advantage, either by the student who wishes to review his former acquisitions, or by the artist, who is obliged to content himself with a concise abstract of the science.

The translation was made from the second edition of the original, omitting, however, a few notes, which were intended as replies to some criticisms on the work, published in one of the French
Literary

P R E F A C E.

v

Literary Journals. In lieu of these, I added a few of my own, relating to some doctrines and facts with which M. Beaumé appeared unacquainted or misinformed.

My opinion of the utility of this work has been confirmed by its reception from the public; which has produced a demand for a new edition. On this occasion, I thought it my duty not to leave the reader unacquainted with such established facts and doctrines as have appeared since the former publication, whereby the ideas of the original author are in some important cases either corrected or extended. But as my own chemical studies had for some time been intermitted, I took the liberty of requesting the assistance of my friend, the Rev. George Cadogan Morgan, who has for a considerable time been assiduously employed in a course of chemical reading and experiment, the result of which will

probably be given to the public, in an extensive collection of chemical facts, formed on the plan of Mr. Beaumé's larger work. He has kindly furnished me with a number of notes for my purpose, with which I have enriched the present edition. They are distinguished by the letter M. affixed.

I. A.

A MANUAL

A

M A N U A L

OF CHEMISTRY.

I N T R O D U C T I O N.

CHEMISTRY is a science founded on experiment. Its object is the analysis or decomposition of all the bodies in nature; and the combination of all these bodies, or their principles, with each other, for the purpose of forming new compounds.

Mechanical division does not decompose bodies; it only divides them into more and more minute parts, but still homogeneous and of the same nature. Mechanical division is therefore totally insufficient for the analysis of bodies; and it

is necessary to have recourse to other instruments less confined in their action. The elements, or primitive principles of bodies, of which we are soon to treat, become, in the hands of chemists, instruments fit for producing these divisions, and for separating the constituent parts of bodies. It is this latter kind of division that is termed the *analysis*, or *chemical decomposition* of bodies.

GENERAL IDEA OF THE UNION AND COMPOSITION OF BODIES.

When several particles come insensibly into union, they form a larger mass. When this mass is formed of parts of the same nature, or homogeneous, and becomes evident to the senses, it forms what Becher and Stahl have termed *aggregation*; and they have called the mass resulting from this union an *aggregate* or *aggregated body*, because it produces only an addition of particles of the same nature, or a mass merely larger in bulk, and not a composition.

But when two bodies of a different nature join together, there results from this union a new mixed body, which partakes of the properties

INTRODUCTION. 3

ties of each of the component bodies. This is what Becher and Stahl have termed *mixture*, and what we shall call the *combination* or *chemical composition* of bodies.

We shall give the name of *compound bodies* to those which are formed by the union of parts of a different nature. These heterogeneous parts are termed *principles* or *constituent parts*, which it is of importance clearly to distinguish from *integrant parts*. Natural philosophers understand by integrant parts the smallest *moleculæ* of an extremely divided body, which is not susceptible of a further division without decomposition.

ON AFFINITIES.

In Chemistry the terms *relation* or *affinity* are used to express the tendency which the particles of matter have to unite or combine with each other, whether these particles are of the same, or of an absolutely different nature. Chemistry and Natural Philosophy are not as yet sufficiently advanced for the explanation of the cause of this phenomenon, which is a general one, and perpetually met with in nature and in all the operations of chemistry.

A 5 Some

Some Chemists, without having sufficiently examined the properties of bodies, have ranked chemical affinities among the number of those ingenious systems which are formed only to subsist till new ones spring up to destroy them; but this is by no means the case with respect to these affinities, which, on the contrary, are a property inherent in matter.

Several able chemists, who have considered the science in a more general point of view, have recognized this inherent property of matter, and the disposition which certain bodies have to unite with each other; they have remarked that there are some which unite with great facility, while others do not combine but with much difficulty, and a third set refuse to enter into the least union by any methods as yet discovered. It would be wrong, however, to conclude that these bodies have no affinity, because we have not as yet found means to make them unite; on the contrary, there is every reason to suppose that the effect might be produced by more studied methods.

To determine by a sufficient number of experiments the order in which different bodies will
unite

unite successively with each other, is one of the most important services that can be rendered to Chemistry. The late M. Geoffroy the physician was the first who thought of comprizing in a table the fundamental relations or affinities in Chemistry. Although this table be liable to various exceptions and alterations which we shall remark as occasion offers, it ought, however, to be regarded as a master-piece in its kind; and may serve as a chart or guide to all who desire to perfect or augment it. It forms a kind of connected series of knowledge, which has thrown more light upon Chemistry and Physics than all the criticisms which have been made upon it to the present day.

M. Geller has considerably augmented this table; but I conceive it would be most advantageous to give two such tables at once; one of which should present the order of the affinities of bodies by the *moist way*, the other, the same order by the *dry way*. There are in Chemistry an infinite number of circumstances, which will be pointed out, in which bodies that shew no affinity by the moist way, do by the dry way; and *vice versa*. This is what has led me to ima-

A 6

gine

gine that the double table which I propose would be extremely useful.

M. Macquer has treated on what relates to affinities at large in a particular memoir, which is the subject of one of our chemical lectures. He lays down a methodical division of affinities or rather a division of the different states in which affinities are met with in the operations of Chemistry; though otherwise he admits only a single species of affinity, which is absolutely the same, and which he traces as proceeding from the same cause. He arranges all the chemical affinities under seven classes.

I. AFFINITY OF AGGREGATION.

The affinity of aggregation is the power which causes two homogeneous bodies to tend towards each other, and to cohere after they are united. Such, for example, is the cohesion of two polished surfaces applied to each other, or the movement which two drops of a homogeneous liquor, placed near each other, make to come into union.

2. SIMPLE

2. SIMPLE AFFINITY OF COMPOSITION.

Simple affinities of composition are those from which new combinations result. Such are the solutions of bodies in acids. If, for example, white marble is put in some nitrous acid, it dissolves in this liquid, and the compound which results has properties participating of those of the acid and the earth.

3. COMPOUND AFFINITY.

Compound affinities are those of heterogeneous bodies which have mutually an equal affinity, whence results a mixture without any decomposition. But the compound has properties different from those of each of the bodies separately. For example, if four drams of lead, and as much tin are melted together, and two drams of mercury are added to this mixture, the mercury unites with the two bodies, because its affinity to each of them is nearly equal; and the product is eager, brittle, and more fusible than the tin and lead separately. These properties
proceed

8 INTRODUCTION.

proceed from the mercury, which has only a fluid consistence.

4. AFFINITY BY MEANS OF A MEDIUM.

Affinities by means of a medium are those of bodies which are unable to enter into union except through the addition of some other body which has an affinity with each of the primitive bodies. If water is poured upon white marble; no union takes place; but on adding nitrous acid the water and marble unite. The nitrous acid is the proper *medium* for uniting calcareous earths with water.

5. AFFINITY OF DECOMPOSITION.

Affinities of decomposition are those whence result decompositions and new combinations. To a solution of white marble in the nitrous acid, add fixed alkali. This will unite with the acid, and precipitate the earth of the marble.

6. RECIPROCAL AFFINITY.

Reciprocal affinities are those whence reciprocal decompositions proceed. For example,
nitre

nitre is decomposed by the vitriolic acid, because this acid disengages the acid of the nitre, and combines with its alkaline basis. Thus is formed a vitriolated tartar. But this same nitrous acid, which has thus been detached by the vitriolic acid, being afterwards mixed with the vitriolated tartar, disengages the vitriolic acid in its turn, takes possession of its alkaline basis, and forms with it a true nitre, the same that existed before these operations.

7. DOUBLE AFFINITY.

Double affinities, or affinities of four bodies, are those from which result two decompositions and two new combinations, from the reciprocal changes of the several bodies. Such are, first, the decompositions of vitriolated tartar and Glauber's salt by all metallic solutions in the nitrous acid, and also by vinegar of lead. 2dly. The process for making Prussian blue. 3dly. That in which the butter and cinnabar of Antimony are made at the same time. 4thly. The decomposition of sea salt by solutions of lead and silver. There are in chemistry a great
number

number of similar examples of affinities of four bodies which act simultaneously when mixed together.

The agency of the four substances in this class of affinities, shews that there are bodies which, when in an aggregate mass, are absolutely insoluble in such or such an acid, but which become perfectly soluble when greatly divided. This division is very effectually produced by dissolving them beforehand in that acid or menstruum which agrees best with them. From hence it follows, that if, by any mechanical means, bodies are sufficiently divided, an union may be effected between those that appear to have the least disposition towards combination; and this is what I have, in fact, obtained in many operations which we shall have occasion to mention.

ON THE
ELEMENTS
OR
PRIMITIVE PRINCIPLES OF BODIES.

THE greater part of Philosophers have admitted *primitive principles*; that is to say, bodies of great simplicity, which serve for the formation of all the bodies in nature, but, as we shall presently mention, in a progressive order. To these principles they have given different appellations, as *elements*, *atoms*, *monades*, *proper matter*, &c; and they have sometimes attributed to them properties which were purely relative only to what they proposed to explain.

However

However this be, and under what denomination soever the primitive principles of bodies be considered, we ought to conceive of them as essentially of the greatest simplicity, without constituent parts, and on account of the tenuity and subtilty of their particles, not perceivable or cognizable by any of our senses.

Stahl has reasoned a good deal upon these simple principles, and has employed them advantageously in elucidating the theory of Becher and establishing his own. But whilst he explains himself clearly concerning the simple and homogeneous nature of these principles, he does not with the same precision determine whether we ought to admit several species of them, which are heterogeneous with respect to each other, and possess different properties. In fact, it is impossible for us to acquire the knowledge of this subject.

He shews only that this was his opinion; and, in reality, it appears difficult to conceive how a single simple and homogeneous principle can form all the different bodies existing in nature.

The

The *moleculæ* of this single principle by uniting should only form aggregations, which would always be of the same species, and not compounds. It appears reasonable, therefore, to admit several kinds of principles equally simple, but differing from each other in properties. We imagine it to be difficult to determine their number; and the reasons of this will be better perceived when we shall examine the properties of the true principles of bodies, or at least of those which we ought to regard as such.

What Becher and Stahl term *secondary principles*, *principled principles*, or *mixts*, are the bodies which are formed directly by the combination of the different simple principles which we have just mentioned. These compounds of the first order form, according to Becher and Stahl, FIRE, AIR, WATER, and EARTH. They partake considerably of the properties of the substances whence they are formed; that is, they have still such a degree of simplicity as to be indestructible and unalterable by all our chemical analyses. In a word, all the efforts made to the present time to decompose them, have

have been totally insufficient.* For this reason, we shall name them *elements* or *primitive principles* of bodies. The union of these principles, their different proportions and methods of arranging themselves, produce all the variety of bodies which exist in nature. We shall demonstrate these truths in a large detail, by giving the analysis of the bodies of the different kingdoms.

Becher and Stahl, pursuing further and further the combinations of the primitive principles, and of those which they term secondary, establish different orders of compound bodies, to which they give improper denominations. The signification of many of these terms is even contrary to the ideas usually affixed to them, and is liable to occasion obscurity.

The bodies which they name *compounds* are those formed by the union of their secondary principles; those which they term *decompounds* are such as are formed by the union of com-

* Common or atmospherical air must be excepted, as will be presently shewn. J. A.

pounds;

pounds; and they call *super-decompounds* those which result from the union of compounds. This, in a few words, is the whole theory which Becher and Stahl have laid down with regard to simple principles, and the combination of these principles to form more compound bodies, and thus in an indefinite progression.

It appears to us much more convenient to adopt the denominations given by M. Macquer to these different orders of compounds. He terms them *compounds of the first order, of the second order, &c.* which leaves no room for any kind of obscurity.

Chemists have not always agreed among themselves concerning either the number, or the nature of the principles of bodies. Paracelsus admitted as principles the products which animals and vegetables furnished during their analysis. Of these he establishes two species, the *active* and the *passive*. His active principles are three in number, SPIRIT, OIL, and SALT; his passive, two, WATER and EARTH.

By *spirit*, or *mercury*, he understands salt dissolved in water; by *oil*, or *sulphur*,
all

all oily liquors; by *salt*, all saline matters; by *water*, which he also termed *phlegm*, all watery liquors; and by *earth*, all fixed matters.

This doctrine, established by Paracelsus, was adopted by the chemists of his time, and has been followed by several of the more modern. But Paracelsus and those of his sect have considered as principles, substances which are not so. They have not, by any means, the simplicity of real principles; on the contrary, they are, as we shall find, masses of compounded substances, very different among themselves, and which may be reduced into others much more simple.

Becher, perceiving the obscurity of this theory, attempted to rectify it. He established only two principles or elements of bodies, *water* and *earth*; but that he might be able to account for the properties of all compound bodies, he admitted three kinds of simple and elementary earths. The first of these he termed *vitriifiable earth*, the second, *imflammable earth*, and the third, *mercurial earth*.

Vitri-

Vitrifiable earth, according to him, is the principle of fixity and hardness in bodies, and of vitrification.

By inflammable earth he understands that which contains the principle of inflammability.

And by mercurial earth he means the principle of metallisation ; that is to say, that which combined with the other two, is proper for the formation of metals.

Stahl, in rectifying, in his turn, the theory of Becher, has proved after a satisfactory manner the existence of the two first earths ; but he calls into question the existence of the third, as not appearing to him sufficiently demonstrated.

In agreement with the best chemists and natural philosophers, we ought to regard WATER, FIRE, and EARTH, as the elements or true primitive principles of bodies. To these three, may be added AIR : the experiments of Boyle, and particularly those related by Hales in his *Vegetable Statics*, shew, at least, that this element

ment makes a part of many compound bodies, and that it is one of the constituent principles of organised bodies.

Nature presents to us these four elements or primitive principles under two different states; 1st. detached, not making part of any compound body, and in a state of purity sufficient for being recognized: 2dly. combined with each other in an infinite variety of ways, and in all kinds of proportions, forming all the compound bodies with which we are acquainted.

We shall examine the properties of these elements in both these states; and first those which they possess when not constituting a part of any body. When we come to treat of the analyses of bodies, we shall investigate their properties in those compounds of which they make a part.

O N F I R E.

FIRE is a matter essentially fluid, the principle of fluidity in other bodies, and always
in

in motion. It is the principal agent and cause of almost all the compositions and decompositions which take place in nature.

Fire, with respect to us, is a simple element, appearing to have no constituent parts; however, as the light which proceeds from the sun may be decomposed into seven different colours by means of the prism, and as these differently coloured rays have, moreover, each their proper refrangibility, we may suspect that fire is composed of parts, very simple indeed, but heterogeneous with regard to each other.* This reflexion adds probability to the opinion of those philosophers who think that the bodies which, on account of their simplicity, we are obliged to regard as elements, are themselves compounded of still more simple substances. However this be, we shall consider elementary fire as not having con-

* Mr. Beaumé seems to regard light and fire as the same bodies. The different effects which in similar circumstances are produced by them; the appearance of light in several cases without heat, and *vice versa*, of heat without light, afford sufficient reasons for doubting any theory which is founded on their identity, or, on the supposition that in all cases they act as one and the same element. M.

stituent parts, till the sphere of our knowledge is more enlarged in this respect.

The particles of which fire is composed have scarcely any mutual cohesion. They are of an inconceivable smallness, surpassing that of other bodies. We shall consider fire under two different states.

When it is pure, detached, and not a part of any compound, it has an action upon all bodies, and even becomes an instrument proper for analyses and recompositions.

When it is combined with other substances, and makes one of the constituent principles of compound bodies, it is inactive, and in perfect repose, and cannot put itself in motion but when it is excited.

The signs by which the presence of fire is discovered are the effects which it produces; *viz.* 1. heat, 2. light, 3. colour, 4. the dilatation or rarefaction both of fluids and solids, 5. combustion, fusion, &c.

Some philosophers think that light is a certain sign of the presence of fire; but this may
be

be questioned, since heat and light may exist without each other. A very hot iron gives no light in a dark place, and yet is in a state capable of inflaming combustible bodies: the focus of a concave mirror is not luminous, although it is of such excessive heat as to be capable of instantly fusing and vitrifying the hardest bodies.*

It is the same with respect to light: it may exist without heat. The rays of the moon, collected by means of a concave mirror, or a large lens, form a very luminous point,† which, received upon the ball of a thermometer, indicates not the least heat.

An unequivocal proof of the presence of fire, is the dilatation which it occasions in all

* Perhaps the heat which fire manifests wherever it is present, is only occasioned by the action which it exerts on the bodies it touches. It is difficult, and perhaps impossible, to support this opinion by experiments; I offer it, therefore, only as a conjecture founded on some probabilities.

† Surely the point formed by the collected lunar rays is not more luminous than that of the solar rays. When the focus falls in the air it is not visible in either case; but received upon any body capable of reflecting the rays, those of the sun are strongly luminous, as well as those of the moon. J. A.

bodies. It penetrates all with extreme facility, distributing itself uniformly through all parts of their masses. None is capable of resisting its action. When it has introduced itself into bodies, it dilates them, warms them, and causes them to occupy a greater bulk than before, without augmenting their weight:* it, however, dilates liquids and bodies of rare texture more readily than those which are solid and very dense.

Cold, which is only the absence of part of this fire, produces a contrary effect; that is, the less bodies are penetrated by fire, the more they lose of their bulk, without losing any of their weight. They consequently increase in specific gravity and hardness, because their particles become more closely joined to each other.

* The addition of heat to a body on the supposition of its corporeal nature instead of increasing ought to diminish the weight of that body. On the same principles that air added to a body would diminish its weight in water. So should heat added to a body diminish its weight in air. From several experiments made on large masses of red hot iron, by Mr. Whitehurst, we have every reason to believe that this is actually the case. M.

This

This property of fire easily to penetrate and dilate bodies, has been advantageously applied in the construction of thermometers. These instruments, perfected by the illustrious Reaumur, are of great service in measuring degrees of heat and cold which could not be estimated by any other means.*

There is no body which is not continually penetrated by a greater or less quantity of this pure fire, always in proportion to the quantity contained in the ambient air. This fire perpetually flies off and re-enters, as by a kind of circulation, according to circumstances; because it is not combined with, but only interposed between, the particles of the substance. Those bodies which excite in us sensations of cold, are still penetrated by a large quantity of fire. One may, indeed, deprive them of part of this fire: for example, one may cause ice to undergo an artificial cold greater than that of its proper temperature; but hitherto it has proved impossible, by the greatest degree of cold we can excite,

* Those only who are strangers to Mr. de Luc's excellent Treatise on the Atmosphere, will agree in this opinion of the perfection of Mr. Reaumur's Thermometer. M.

artificially to deprive bodies of all the fire they contain. The absolute cold, or total absence of fire, which some philosophers have conceived, is as chimerical as absolute heat: we cannot have clear ideas of these two extremes, still less can we produce them.

The dilatation which fire occasions in bodies is a beginning disunion of their parts, and a proof of the property which fire possesses of decomposing substances, and separating their constituent parts. But, as there is a difference between bodies, fire will not decompose all with equal facility. The celebrated Boerhaave says, on this head, that there is in bodies a matter which is not fire, and which resists the separation of their principles; but we imagine this effect can only be attributed to the more or less intimate combination of the constituent parts of bodies, and their greater or less adhesion to each other.

The more bodies are heated, the more they dilate; but this dilatation ceases in bodies susceptible of fusion as soon as they are melted, because they can then no longer retain the fire, but suffer it to dissipate as fast as they receive it.

It

It is the same with liquids. We may consider them as perpetually in fusion, since they are brought to a state of solidity by cooling them sufficiently. Ebullition is the highest degree of heat they can receive,* and those which are with the greatest difficulty made to boil, acquire the greatest heat. It is from this cause that oil, for example, though lighter than water, admits of more heat. But mercury, although fifteen times heavier than oil, does not take a greater degree of heat when boiling, because it is of a volatile nature. Thus the greatest degree of heat that liquids can receive, is not in proportion to their specific gravity, but their fixity only.

Fire has some adhesion to the bodies which it heats; but it is not combined with them, since it dissipates as they cool; and there remains at last only a quantity equal to that in the surrounding air.†

Bodies

* Mr. Beaumé should have qualified this expression, by saying, that the heat of ebullition is the highest which fluids can receive under the common pressure of the atmosphere. For when confined in a Papin's digester, even water may be heated so intensely as to fuse metallic bodies. M.

† In several cases, there is a loss of heat, which can be accounted for only on the supposition that it has become a constituent part of the body which received it e. g. An equal

Bodies of the greatest specific gravity retain pure fire the longest.* It dissipates quickly during the first moments; but when the substances are cooled to a degree approaching the temperature of the ambient air, the remains of fire which they contain are much longer in separating.

It is not certain whether or no fire is weighty. There are experiments on both sides the question. Boerhaave relates that he caused a bar of iron which he had before weighed, to be made red hot, and that he marked no augmentation of its weight. In another part of his excellent *Treatise on Fire*, he observes that metals calcined by a burning glass increase in weight considerably, some a sixteenth, others a tenth. But it

weight of water at 33° . mixed with water at 212° . will assume the temperature of 100° ; whereas a similar mixture of snow at 32° . and water at 212° . will sink the thermometer to 58° . In this fact the difference in the temperature of the ingredients before mixture is trifling, but after mixture it is very great; and the loss in the last mixture is to be sought for only in that absorption of heat which was necessary to convert water from a solid to a fluid state. M.

* Metallic substances must be excepted, which receive and part with heat quicker than other bodies.

seems,

seems, as this author remarks, that all the necessary precautions for ascertaining the cause of this augmentation have not been taken. He supposes that it proceeds from the vessels being destroyed and mingled with the calcined matter. He even asserts that metallic substances calcined in glass vessels receive scarcely any addition of weight. I have repeated this experiment with care, and have observed that lead calcined in glass vessels, under the muffle of a cupelling furnace, is augmented in weight a tenth; and I imagine this augmentation can only be attributed to the combination of the fire with the calx of lead*, especially as the capsule of glass suffers no diminution in this experiment.

After having mentioned the principal properties exerted by fire on bodies, we shall next examine the causes which excite it, the means employed to collect it, and the manner in which its action is determined.

The first of these causes is the Sun. This luminary, though remote from us, appears to

* By the experiments of Dr. Priestley and Mr. Lavoisier it is satisfactorily proved that the augmentation of weight acquired in calcining metals is owing to *fixed air* imbibed from the atmosphere. J. A.

be the common reservoir of fire. It comes to us from the sun in a right line, by parallel rays; and perhaps, as some philosophers have conceived, but without any thing like a demonstration, the fire detached from bodies returns thither by a kind of circulation.

The sun's heat is mild, moderate, incapable of producing in bodies changes which might occasion too great an alteration. It is only sufficient to promote the generation, unfolding, and growth of all the beings which live, vegetate, or combine, on the surface, or within the bowels of the earth.

Natural philosophers have discovered the method of uniting, and causing to converge to a single point, a certain number of solar rays, by means of lenses and concave mirrors; and thereby of producing a focus of excessive heat, much superior to every other with which we are acquainted, and capable of instantly melting and vitrifying the hardest bodies; which we cannot effect in our hottest furnaces.

Another means of exciting fire, and which produces effects equally violent with those we
have

have just mentioned, is the shock of hard bodies. The collision of a flint and steel produces in an instant a fire as violent as that in the focus of a good concave mirror. The sparks struck from the steel, when collected and examined by the microscope, appear to be particles of iron which have been melted and vitrified. The excessive violence of the heat necessary for the production of such an effect in so short a space of time, may easily be conceived.

A third means by which fire may be excited, is the combustion of bodies, in the composition of which elementary fire has entered as a constituent principle, and which contain it in large quantity.

All the bodies in nature contain a portion of this fire, some more, others less. Those which possess a large share, as vegetable and animal substances, are called *combustible bodies*, or aliment of fire, because they serve to sustain it. All really terrestrial and metallic substances do not contain enough to serve as aliment to fire; they can only be ignited by the assistance of the bodies which we have termed combustible.

The aliment of fire is that inflammable matter which detaches itself from bodies while burning, and which emits flame and light. This fire, brought into action, produces the same effects on the substances it touches, with the concentrated rays of the sun, or strong friction of hard bodies; it warms, burns, and decomposes them, and separates their constituent parts.

During the combustion of bodies, the combined fire is reduced to elementary fire, and dissipated as fast as this takes place. The celebrated Boerhaave, however, is not of this opinion; objecting, that if this happened, the quantity of elementary fire would go on increasing to infinity. This is not observed to be the case; on the contrary, the most exact observations shew that there is always the same proportion of elementary fire, although a great quantity of combustible matters are every day burned. It is easy, however, to reply to this objection, by saying, as may justly be presumed, that the elementary fire detached from bodies unites in the same proportion with other substances, and loses all its properties of free fire, in becoming a constituent principle of those bodies into the composition of which it enters. This is Stahl's opinion;

opinion; but there are yet many *desiderata* in our knowledge of this subject, and perhaps we may never be able to acquire clear ideas concerning it. In fact, it appears very difficult to determine how fire unites with and fixes itself in bodies; and how, in becoming one of their principles, it loses all the properties which we had recognized in it, so far as not to be able to manifest itself without the contact of an actually ignited body.

Boerhaave figured to himself all these difficulties; he examined the different substances procured by the analyses of animal and vegetable combustible matters, and observed that it was only the oily part which, in whatever state it was, could be deemed the real aliment of fire. The others, as the water, earth, and salt, not being combustible, are, he alledges, more fit for the extinction than the sustenance of fire. Experience is conformable to his opinion. Boerhaave further remarks, that these substances, though incombustible, serve nevertheless to augment the activity of inflammable bodies, when present in suitable proportions. He gives the name of *alcohol* to this inflammable principle when in its greatest degree of purity; that is,
when

when it will burn without emitting either smoke or foot: he also ascertains the identity of this principle in all vegetable and animal substances. The principle here understood is the same that Stahl has named *phlogiston*.

The following experiment was made by Boerhaave on this head. He received in a bell what was dissipated by the burning of spirit of wine, and perceived neither foot nor smoke. The condensed vapours were water; the inflammable matter was destroyed and dissipated, and he was unable to obtain it separate. He observes that other bodies are inflammable only by means of a similar principle which they contain, and that after this is separated by combustion, what remains of the body is not inflammable. He proposes a question to himself, whether, in case this matter were separated from every foreign substance, it would burn quietly and in succession, as happens when it is mixed with water in spirit of wine, or would be consumed, like lightning, instantaneously. Without deciding the question, he concludes that this matter, from whatever substance procured, would be extremely pure, simple, perfectly combustible, and would also yield a very pure flame, without
foot

foot or smoke. Hence he conjectures, that *this principle is a compound of fire, and a very subtile matter which is intimately united with it*; and that nothing in Physics, perhaps, is so difficult to come to the knowledge of, as this purely inflammable part of combustible bodies, which serves as aliment to fire; the more so, as when this matter burns, it is destroyed, and becomes so extremely subtile as not to be cognizable by our senses. He adds, that to the present time, nothing satisfactory has been taught concerning the changes which this matter undergoes during its combustion.

I quote here the opinion of Boerhaave, in order to justify this eminent philosopher from the accusations of ignorance in this matter, which some chemists have brought against him, for want of having collected under one point of view the different passages in his *Treatise on Fire* which relate to this subject, and which unfold all his theory concerning this interesting object. I do this the more willingly, as the reader will thereby be enabled to judge of the resemblances and differences between the ideas of two celebrated authors, who were employed at the same
time

time on the same subject, though in different views.

Boerhaave considered fire and its properties in the manner of a great natural philosopher, and Stahl in that of a great chemist; and, indeed, on a more general plan than Boerhaave. They both agree, however, concerning the general and fundamental properties of the principle which Boerhaave terms alcohol, and Stahl, phlogiston. Stahl discovered the existence of this principle in metallic substances; whereas, Boerhaave, having had other objects in view in his examination of this principle, entirely neglected to ascertain its existence in mineral and metallic bodies.

ON THE PHLOGISTON.

From the ideas of Stahl and Boerhaave concerning the phlogiston it follows, that we are to consider it as a compound substance, formed from the direct union of elementary fire with a very simple matter, as yet unknown to us. There is reason to presume that it is a very subtle earth which thus fixes elementary fire. It
is

is probably in this state of combination that fire enters as a principle into the composition of bodies.

Fire, certainly, can only be in two states, pure or combined. If it be pure, it is elementary fire, and then it acts upon all the bodies it touches, as was said in my definition of fire. In this state it is not phlogiston.

Phlogiston, on the contrary, is this same elementary fire combined with the least possible substance, which causes it to lose all its properties of pure fire. It is in this state of combination that fire acts so great a part in chemistry, and presents a great number of phenomena, without having the property of inflaming or heating bodies, in whatever quantity it is accumulated, unless inflammation be excited, either by means of the application of fire actually in action, or some violent fermentation produced in the mixture which contains it.

The phlogiston ought to be regarded as a true secondary principle, formed by the direct union of elementary fire and some other substance,

stance, since it may be decomposed, and the elementary fire separated from it.*

We have already remarked the ineffectual attempts that have been made in order to obtain the phlogistic principle in a detached state. Since the time of Boerhaave and Stahl chemistry is not at all advanced in this respect. We are still only able to examine its properties. These are too general to be described here: we shall content ourselves at present with making mention of those which it is necessary to know in order to understand what has just been said; intending to speak of the rest as occasion offers.

1. Phlogiston is the principle of odour and colour.

2. This principle is identical, that is, of the same nature, from whatever substance it is drawn.

* Since this work was written, various attempts have been made by eminent chemists and philosophers to investigate the nature and existence of this principle; but the subject is, notwithstanding, yet involved in all the darkness and uncertainty of speculation and conjecture. M.

3. The

3. The purest state in which we can retain it in inaction, is when it is combined with only a very small number of other substances; as in charcoal, in metals, and in those inflammable matters which burn without soot or smoke, such as spirit of wine and sulphur.

When it is in the igneous motion, it is decomposed and dissipated. It then, according to circumstances, produces mortal effects. Let us examine these different circumstances.

When charcoal is burned in a close chamber, the organ of smelling is very sensibly affected; but this invisible vapour affects the brain still more strongly, and destroys entirely or in part the spring of the air. Death presently follows, if the person does not withdraw as soon as he begins to perceive these effects. But the like does not happen when spirit of wine is burned in the same manner; nor even when charcoal is burned in a chimney or a stove in which the external air can circulate freely.*

The

* The fatal effects of burning charcoal in a close room are most evidently produced by the deposition of a certain quantity of fixed air, which is separated from the atmosphere by the combustion of the coal. If a pan of boiling water be placed
in

The effects which take place in the first case proceed from the vapours of the charcoal which circulate in the air of the chamber, and which are nothing else than a portion of the phlogiston raised by the act of combustion, and which has not had time to burn and be reduced to elementary fire. Its effects on those who are exposed to it probably arise from the great disposition which the phlogiston, reduced to this state, has to combine with all the bodies it meets.

It will perhaps be asked why the vapours of burning spirit of wine do not produce the same effect. I answer, that there enters into the composition of this liquor a great quantity of air and water, which detach themselves during its combustion, and suffice to replace these substances in the air as fast as the phlogiston of the spirit of wine absorbs them while it burns.

In the room, the steam will absorb the mephitic principle as soon as it is formed, and will entirely prevent the inconveniences which might otherwise be felt.

The disagreeable sensations which we experience when confined near a large surface of new paint, are lessened, if not entirely removed by a similar process: and for the same reason the watery vapour which escapes during the combustion of spirits of wine will produce the effect described by this author. M.

This

This appears to me the more probable, as oily matters, which contain less water than spirit of wine does, produce similar effects with charcoal when burned in a close place, though in a less degree, because they always contain a certain quantity of air and water, of which charcoal is entirely deprived. These pernicious effects do not take place when the charcoal is burned in a chimney or stove where there is a free circulation of air, because the phlogistic vapours are continually carried off by the current of air. Besides, it is only the pure and elementary fire which filters through the pipes of the stove; the phlogistic vapour cannot do so.

The other properties of phlogiston are too many to be enumerated here.

O N A I R.

AIR is an invisible, colourless, insipid, inodorous, weighty, elastic fluid, susceptible of rarefaction and condensation, and affecting none of our senses, unless it be that of the touch.

This

This fluid environs the terrestrial globe, and serves to sustain the life of the animals which exist on its surface. The experiments with the air-pump have shewn that those animals which cease to breathe air immediately perish.

Air as well as fire, is under two different states.

1. Pure, detached, and not making a part of any compound body: 2. combined with other substances, and serving as a principle or constituent part of many compound bodies, particularly of the vegetable and animal kingdoms.

We shall first enumerate the most general properties of air in a pure and detached state.

Air is always fluid, like fire; at least to the present time, philosophers have not been able to render it solid, even by the aid of the highest degrees of artificial cold.

The fluidity of air is absolutely necessary for the support of animal and vegetable life. It would be extremely melancholy if this element, like

like water, were capable of being rendered solid by moderate cold. Boerhaave conjectures that the fluidity of air may proceed from the particles of fire which are always mixed with it, and which are absolutely inseparable from it. The difficulty of producing a sufficient degree of cold is perhaps the only cause why air has never been met with solid: it is a body which requires a very moderate degree of heat to keep it in the state of fluidity in which we are accustomed to find it.

Air, as we have already said, cannot be perceived by the organ of sight: it is absolutely invisible, because colourless. It is likewise absolutely insipid and inodorous when perfectly pure; but it very readily becomes charged both with good and bad scents. When it is in agitation, it carries to considerable distances the odours with which it is impregnated; it seems even to be the reservoir of bodies which are in a state of extreme division, and reduced to particles of as great tenuity as itself: for this reason it is difficult to find air perfectly free from foreign matters. It is always loaded with moisture, which appears even to be essential to its use in respiration.

Next

Next to fire, air is the lightest matter with which we are acquainted. This is the cause of its always being on the surface of those bodies with which it is not combined. In general, it penetrates only into those places where it finds no substance heavier than itself. It is on this property of air that all the mechanism of furnaces of which we are soon to speak is founded.

We might here enumerate a great number of experiments which prove not only the weight of the air, but its relation to the greatest part of known bodies; but for these things, which appear useless in chemistry, we refer to the books of Natural Philosophy.

Air is elastic; that is to say, it yields to compression, and returns to its former state as soon as the compressing power is removed. It loses nothing of its elasticity, as other springy bodies do, either by being too much compressed, or kept too long in a state of compression. Air has been kept a prodigiously compressed state during fifteen or twenty years, without the least perceptible diminution of its elasticity.

The effects of fire on air are to dilate or rarefy it, that is, to make it occupy a greater
space

space than before. The greatest dilatation it can undergo from the most violent fire, is to thirteen or fourteen times its bulk. It can never be so far rarefied as to leave a perfect vacuum; a part of the air always remains, even when the containing vessel is brought to a white heat. We shall not relate the experiments proving this point; they may be read at large in the books of Natural Philosophy. When the air cools again, it is condensed, that is, its particles approach each other, so as to occupy no greater space than before.

Air, as we have said, enters into the combination of many compound bodies, and even becomes one of their constituent principles. When thus combined, it loses all its properties, and becomes what Dr. Hales terms *solid air*, that is, air rendered solid by assimilating with animal and vegetable bodies.*

Perhaps

* The air which thus becomes a principle of bodies, not only during the time of its combination has different properties from common air, but after its separation appears with different qualities. This kind of air, termed *fixed* or *fixable*, contrary to the atmospherical, is destructive to light and flame. It easily combines with water, and gives it an acid impregnation.

C

Perhaps air does not enter into the composition of bodies till it is united with some principle as yet unknown to us. In this case it would exist there under the form of a secondary principle, as fire under that of phlogiston. However this be, we ought to make a proper distinction between this combined air, and that which is interposed between the particles of bodies. The latter may be separated by mechanical means; whereas the former can only be expelled from bodies by decomposing them.

Boerhaave on this subject says, that an insulated particle of air is not elastic, and that it acquires this property only when it is united with others; which takes place by the union of those particles of air which are detached from bodies submitted to a chemical analysis.

We shall not undertake at present to demonstrate the existence of air as performing the function of a principle in vegetable and animal bodies.

It is separated from bodies in all fermentative and effervescent processes, and in some cases by calcination. It seems not yet clearly determined whether this is a different species of air from the atmospherical, or only a part of it; though the latter opinion appears most probable. J. A.

This

This would engage us in details which would suppose the knowledge of a great number of things that must be first treated of. We have just considered the effects of fire upon air; let us now examine those of air upon fire.

Air is the vehicle of combustion. Without it no combustible bodies can be burned: they are even extinguished though well kindled when all communication with the external air is cut off. Many able philosophers imagine that the weight and elasticity of air are the only causes which render it proper for keeping up combustion. By means of these properties, it unites and assembles the active fire, and applies it immediately to the combustible matters which remain to be burned.

This theory appears insufficient for the explanation of the following phenomenon. Black charcoal is put into a box of iron or earth exactly closed; this is placed in a furnace and heated to a white heat. How violent and how long continued soever the heat is, it is found, after the box is cooled, that the charcoal has lost nothing of its weight, and that it has undergone no combustion. It is, however, certain, that the matter of fire, in its igneous motion, has

C 2 continually

continually been very intimately applied to it, and that the inflammable matter of the charcoal itself has been in a kindled state.

It may be conjectured with a good deal of probability, that the charcoal in this experiment does not burn, because it is deprived of air, and of all those matters which perform the office of air in becoming considerably rarefied on numerous occasions, but which cannot be volatilised in close vessels. The inflammable matter in charcoal is not susceptible of any dilatation; it is even, as we have remarked, more fit to absorb air during its combustion, than to furnish it. The charcoal in this process is penetrated with fire, but a fire foreign to it. Its own inflammable matter does not consume, because it is incapable of dilatation.

It will be urged, that neither do vegetable or animal bodies, though containing much air, with oily and aqueous matters, &c. burn during their analysis; but this is owing to the fire being raised by degrees, in order to detach these substances in succession. Experience has shewn, that when the fire is pushed hastily, explosions are occasioned, which may arise as well from the inflammation,

inflammation, as the dilatation, of these volatile parts.

From what has been said, it evidently follows, that the concurrence of the air is absolutely necessary for the combustion of bodies. It is upon this property that all the mechanism and construction of furnaces is founded.

ON FURNACES.

A furnace is a machine formed so as to admit a current of air, and to contain, retain, and apply the fire to the vessel in which is placed the subject to be operated on.

The furnace designed for producing the greatest degree of heat ought to have a large ash-hole, by which the air may enter freely; its upper part, or chimney, ought also to be very wide. There should be no other opening; at least, if it be necessary to make one for convenience, it should be capable of being closely shut, that the current of air may not enter at many places at once.

The flame arriving at the upper part of the furnace, rarefies the air prodigiously, and makes a more or less perfect vacuum. The air, entering through the ash-hole, passes across the fuel with a rapidity proportioned to the completeness of the vacuum, which thus produces the effect of a pair of bellows.

The air cannot enter by the chimney or upper part of the furnace because the flame continually expels it, and also because that part is filled with a matter which continually tends to fly off, and opposes the introduction of the air. It is consequently obliged to enter at the lower part of the furnace, where the flame does not go out. *

ON WATER.

WATER is a liquid, transparent, colourless, inodorous, insipid substance. By a mode-

* This fact is better explained by saying that the column of air which presses at the bottom of the furnace is heavier than that which presses on the top in proportion to the perfection of the vacuum in the furnace, therefore the air cannot rush down through the chimney, unless the violence of some descending wind should be sufficiently powerful to counteract the effects of gravity. M.

rate

rate degree of cold it is converted into a solid transparent body, called *Ice*.

Water becomes rarefied by heat, is augmented in bulk, and quietly disperfes in vapour when the degree of heat is incapable of bringing it to a ftate of ebullition.

Water which boils with great bubbles in the open air has received the greateft degree of heat that it can fustain in open veffels. This is demonftrated by the thermometer, which immerfed into water in this ftate, ftands at from 80 to 84 degrees according to Mr. Reaumur's fcale.* But when it is confined, and not fuffered to evaporate, as in Papin's digefter, it acquires heat enough to melt a piece of lead or tin fufpended in its centre, and to decompose vegetable and animal fubftances, nearly in the fame manner as when they are analyfed in a retort.

When water is made fuddenly to undergo a white heat, it is diffipated with fuch rapidity as to make a terrible noife and explofion. It

* The boiling point of water according to Fahrenheit's fcale is 212. J. A.

acts like a spring let go, which overthrows every thing in its way.

Water, in the mass, is neither elastic nor compressible like air. The experiment of the Florentine Academy proves that it will pass through the pores of a metal vase in which it is enclosed, rather than suffer itself to be compressed. *

This element, in all chemical experiments, undergoes no decomposition or alteration. At every distillation, indeed, a small quantity of earth is separated from it; but this, by every experiment appears to be a foreign matter. †

* The Florentine experiment is by no means a proof of the absolute incompressibility of water; for though the change of a spherical vessel filled with water into an oblate form forced out some water at the sides, yet it does not hence appear that the quantity of water forced out is adequate to the change of figure. Mr. Canton has treated this subject in the Philosophical Transactions with his usual clearness and ingenuity. M.

† The change of water into earth has been believed and maintained by many of the most eminent amongst chemical philosophers. But it is evident from the experiments of Lavoisier, and particularly of Fontana, that by longebullition the sides of a glass vessel are corroded by the water, and that siliceous particles are by this means suspended in the fluid, and therefore separated in the form of a fine powder, when the water is evaporated. M.

Water

Water enters as a constituent principle into the composition of animal and vegetable bodies. It serves to the formation of minerals; but all enquiries that have been made to the present time, prove that it does not enter into their composition.

All the water with which we are furnished by nature constantly contains a quantity, greater or less, of saline and earthy matter. Distillation has the property of separating these foreign substances.

DISTILLATION OF WATER.

River water is put in a glass alembic, and about two thirds of the quantity is drawn off by a moderate heat. The remainder is thrown away as useless. It is loaded with the foreign fixed matters which the water held in solution.

O N E A R T H.

ELEMENTARY earth is not so easy to be recognized as the other elements, the principal

C 5

properties

properties of which we have ascertained. This difficulty arises from the prodigious variety of stones and earths which nature offers us.

Many able chemists have made incredible efforts to investigate it, but without success. However we may regard as elementary earth that which is the purest, and which possesses the greatest number of the properties of the earthy principle.

All these conditions are united in pure diamond, or very clean and transparent rock crystal.* If these substances are not elementary earth, they afford at least the purest earthy substance with which we are acquainted.

The Chemists, in examining a great number of stones and earths, remarked that there were

* Mr. Beaumé has very unfortunately fixed upon the diamond as a specimen of the purest earth; for by the admirable analysis of Bergman, it appears to consist chiefly, if not wholly, of an inflammable substance, which volatilizes on exposure to the heat of melted silver. See his *Treatise on Gems*, vol. II. *Opuscul.*

The rock crystal likewise is far from any approaches to our ideas of an element; for one hundred parts of it contain six of argillaceous earth and one of calcareous. See *Bergman*, vol. II, p. 112, or *Mr. Kirwan's Mineral*, p. 104. M.

many

many which had similar properties, and others which differed essentially among themselves. This led them to establish several species of stones and earths. The Naturalists, too, have given their divisions; but as these do not always agree with chemical experiments, we shall not particularize them.

Becher, as we have said above, admits three kinds of earths, viz. a vitrifiable, inflammable, and mercurial earth.

Stahl, in his amendment of Becher's system, admits only two kinds, the vitrifiable and calcareous. He supposes that all the others are only different modifications of earth. He absolutely rejects the mercurial earth of Becher, which, in fact, is far from being demonstrated.

Mr. Pott receives four species of earth; the alkaline or calcareous, the gypseous, the argillaceous, and the vitrifiable. He rejects the division of Stahl, because it appears to him too general; but we shall find, in examining the properties of Mr. Pott's four earths, that they are reduced to two. Thus we adhere to Stahl's opinion, and only acknowledge two

C 6 " species

species of earths, the vitrifiable and calcareous. The properties of these we shall now consider, reserving for another occasion what we have to say on gypseous and argillaceous earths.

ON VITRIFIABLE EARTHS.

Vitrifiable earths are under two different forms; in masses, and in dust of greater or less fineness.

Among vitrifiable stones in the mass, some are crystalised, transparent and colourless, as diamond and rock crystal, which are the purest of all; others are entirely or in part opaque; some are coloured by phlogistic or metallic matters, as emeralds, hyacinths, rubies, garnets, &c. There are other vitrifiable stones which are not crystalised, but are found in irregular masses; as flints, quartz, grit-stone, &c.

The vitrifiable earths in dust are sands, which vary infinitely, as well in fineness as in colour.*

* Pure vitrifiable earth can be gained by no other means than that of decomposing the *liquor silicum* by the aid of an acid. M.

Pure vitrifiable earths have neither smell nor taste ; they are not acted upon either by air, water, or earth. They are all heavier than liquids. Vitrifiable stones are distinguished by being sufficiently hard to strike fire with steel.

Sands are as hard as vitrifiable stones in the mass. They are capable of scratching metallic substances, and are successfully used to polish hard bodies.

Pure vitrifiable earths and stones, exposed to the violence of fire, suffer no alteration nor diminution of weight ; they conglomerate a little, but without entering into fusion. It is necessary to add to them some alkaline salt in order to convert them into glass, but a less quantity of salt suffices than for the vitrification of calcareous earths.

We shall examine the other properties of vitrifiable earths as occasion offers.

ON CALCAREOUS EARTHS.

Calcareous, *alkaline*, or *absorbent* earths are the denominations by which those we are going

going to examine are distinguished. All calcareous stones and earths are tender, and easily receive an impression from the point of a knife. The greater part imbibe water when plunged into it.

Calcareous, as well as vitrifiable stones, are found under different forms. Some are in irregular masses, composed of small particles glued to each other, either by a kind of *gluten* unknown to us, or perhaps by the cohesion of aggregation alone. The broken surface of these stones is granulated, and more or less porous like sugar. All the calcareous stones of this species imbibe water with greater or less facility, and retain it strongly; such are lime-stone, white and coloured marbles, chalks, &c. The more porous stones of this class serve for the filtration of water.

There are other calcareous stones which have been crystalised by water, and have all the appearance of vitrifiable stones. These, in general, are of much greater specific gravity than the preceding. They have brilliant *facets* like crystalised vitrifiable stones, and are almost
as

as heavy. They differ from the former only in the arrangement of their parts, having, in other respects, all the properties mentioned in our definition. They are very compact and dense, semitransparent, and do not imbibe water. *Spars* are of this class.

There are other calcareous stones called *stalactites*. These are formed in dripping caverns by means of the water which drains through the earth. This water contains a good deal of earth in solution; and as soon as it comes to the cavern, it evaporates, and leaves its earth attached to the roof, which generally takes a symmetrical arrangement.

A great quantity of calcareous earth is also met with in the form of finer or coarser dust, which has, in other respects, precisely the same properties with those kinds we have mentioned.

The shells of fish, all sea shells, and those of the eggs of birds, are also calcareous earths. They all afford the same phenomena in chemical operations.

Many able chemists have also ranged among calcareous earths, those which are procured from
vegetables

vegetables and from bones by combustion. But they differ from them in several essential properties, and more resemble vitrifiable earths. They hold in some measure a middle nature between vitrifiable and calcareous earths. We shall have occasion to speak of them under the head of vegetable and animal earths.*

QUICK-LIME.

All calcareous earths and stones, exposed to the violence of fire, undergo a loss of substance generally equal to half their weight. This loss only proceeds from the evaporation of the water interposed between their particles, which adheres so strongly, as to make it necessary to keep them a long time in a white heat in order entirely to free them from it. By this operation, calcareous earths and stones are converted into quick-lime.†

LIME

* It is now, I believe, generally admitted that bones are a compound of calcareous earth and the phosphoric acid. M.

† By the experiments of Dr. Black, since repeated and confirmed by other chemists, it is sufficiently proved, that besides the *water* expelled from calcareous earths during calcination, a quantity of *fixed air*, which entered into its composition, and
which

LIME SLAKED IN THE AIR.

This lime, exposed to the air, attracts the moisture from it very strongly, and is reduced to a fine powder, as light as meal. This is what is called *lime flaked in the air*.*

PASTE OF LIME.

When a certain quantity of water is poured upon quick-lime, it penetrates it, and excites a considerable heat, caused by the friction of the particles of the water against those of the earth. The lime, during its extinction in the water, is divided into very fine particles. It retains a great quantity of water, and forms a paste, called *paste of lime*.

which according to Mr. Lavoisier's experiments amounted to near double the weight of the water, is also expelled. It is likewise demonstrated, that from the separation of this fixed air, almost all the properties in which quick-lime differs from native calcareous earth, proceed. J. A.

* Lime by this means recovers its water, but not its fixed air. Whence it still continues (for some time at least) in a caustic state, and will not effervesce with acids. J. A.

MILK

MILK OF LIME.

When this paste is mixed with a good quantity of water, it is diluted, and forms a white cloudy liquor, resembling milk, whence it has been named *milk of lime*.

LIME - WATER.

This milk clears by being left at rest, and the earth precipitates. If the liquor be then filtered, the product is called *lime-water*.

Lime-water has a bitter, acrid, saline taste. This property depends upon a certain quantity of fixed alkali which it holds in solution, and which is formed during the calcination of the lime-stone, by the intimate combination of the phlogiston contained in the stone with the calcareous earth. Lime-water has not so caustic or saline a taste as a common alkaline lye, because lime-stones do not contain phlogiston enough to convert the whole quantity of calcareous earth into alkali, and because the portion of salt which is produced is mixed and combined with a great quantity of earth, the solution of which in water
is

is promoted by the alkali. Thus there results a saline liquor extremely loaded with earth, which takes off considerably from its saline properties.

It follows from this theory, that the whole of a given quantity of calcareous earth ought to be converted into fixed alkali by the addition of a sufficient quantity of phlogiston; and this, in effect, I have been able to perform.

This resolves one of the six problems which I proposed * in the following terms; *To make fixed alkali with materials which contain nothing saline.*

PELLICLES OR CREAM OF LIME.

In proportion as the lime-water evaporates, † a salino-terreous pellicle appears on its surface, which is called *pellicles or cream of lime*.

* In the *Journal de Medecine* for October, 1762, p. 365.

† These pellicles form faster than evaporation can be supposed to take place, and therefore are more probably, according to Dr. Black's theory, formed by the dissolved particles of the lime near the surface recovering their fixed air from the atmosphere, whereby they are rendered insoluble in water, and thus appear in their original form of calcareous earth. It is found by experiment that streams of fixed air introduced into lime-water precipitate all its dissolved earth in the state of a mild calcareous earth. J. A.

MORTAR

MORTAR OF LIME AND SAND.

Paste of lime, mixed with about an equal quantity of sand, forms the *mortar* used in building. This mixture dries in the air, and acquires a great solidity. This effect proceeds from the falino-terreous matter which the paste of lime contains, and which, applying itself over all the surfaces of the grains of sand, adheres strongly to them, and binds them together. The adhesion of this matter to polished bodies is so strong, that when lime-water is suffered to remain for some time in glasses, the matter deposited by it cannot possibly be got off, either by annealing them with sand, or applying acids to them; because it has penetrated into the very substance of the glass.

O N

SALINE SUBSTANCES.

SALINE substances appear to be formed directly by the intimate combination of three principles, viz. water, earth, and the inflammable principle or phlogiston; whence results a compound which is sapid and has middle properties between the three.

The antient chemists thought that salts were formed of water and earth; but they admitted a third principle, which they named *universal spirit*. They thought that different proportions of this third principle formed an acid or an alkaline salt.

Those

Those chemists who have made the most use of this principle in accounting for the formation of salts, have given us no clear ideas of its nature. But, as I have just said, there enters also into the composition of salts a certain quantity of phlogiston; and this is perhaps the principle which they have denominated universal spirit. What we have observed concerning the formation of the saline-terreous matter of lime, and its little taste, countenances a presumption that the different proportions of the three principles which compose salts, and their mode of arrangement, form either alkalies or acids.

The definition of salts in general will then be, bodies composed of earth, water and phlogiston, which are sapid, and have a disposition to unite with water, earth, and inflammable matters.

The saline substance which we shall first examine, is the *vitriolic acid*, or as it has been called the *universal acid*, from its being the most abundantly and universally dispersed through nature. This acid is never found in a native state pure, on account of the great disposition it has to unite and combine with all the bodies
it

it meets. It can only, therefore, be obtained pure by decomposing those bodies with which it is combined. We shall, however, consider it now in its greatest degree of purity; reserving to some other occasion the examination of those bodies which contain it, as well as those whence it is extracted in great quantity.

ON THE VITRIOLIC ACID.

1. The vitriolic acid is a saline substance, almost always in a liquid state; as it is extremely difficult to procure it under a concrete form. When it is pure and well concentrated, it bears the name of *concentrated* or *rectified vitriolic acid*, and improperly that of *oil of vitriol*. This last appellation has been given it on account of its consistence, which nearly resembles that of fluid oil olive.

2. When perfectly pure it is void of colour and smell.

3. It has a violently sharp sour taste, setting the teeth on edge.

4. Its

66 SALINE SUBSTANCES.

4. Its weight is a medium between that of water and earth. A phial containing eight drams of water will contain sixteen of this acid.

5. Exposed to the air it strongly attracts moisture from it, and instead of evaporating like water, loads itself with humidity equal to half as much again as its own weight; thus it gains in absolute weight while it loses in specific gravity.

SPIRIT OF VITRIOL.

6. The vitriolic acid unites with water with impetuosity. When a mixture is made with four ounces of each of these liquids, a noise is immediately produced, accompanied with a bubbling, which causes vapours to rise. The heat which this mixture acquires is equal to that of boiling water. It proceeds from the mutual friction of the particles of the two liquids as they penetrate each other. The vitriolic acid thus let down with water is called *spirit of vitriol*.

7. This acid readily changes into red the blue colours of syrup of violets, tincture of turnsole, &c.

8. It

8. It has a much greater fixity than water, that is to say, it sustains a considerable degree of heat before it is dissipated in vapours. In close vessels this degree arises almost to a white heat.

RECTIFIED OR CONCENTRATED VITRIOLIC ACID.

9. When this acid has been mixed with water, it may be separated from it by distillation. The water being lighter and more volatile rises first, and the more fixed acid remains at the bottom of the vessel, and cannot be raised but by a much greater heat. This operation is called *rectification* or *concentration* of the vitriolic acid, and what remains in the retort has the name of *rectified* or *concentrated vitriolic acid*.

VITRIOLIC ACID COLOURED BY OILY MATTERS.

10. The purest and whitest vitriolic acid instantly receives a brown hue by the addition of oily matters. In order to produce this effect, a few straws are put to some pure vitriolic acid in a glass.

D

VITRIOLIC

VITRIOLIC ACID RENDERED SULPHUREOUS
BY MEANS OF PHLOGISTON ACTUALLY
KINDLED.

11. If pure vitriolic acid be put in a glass, and a live coal plunged in it, there immediately rises a great quantity of white, thick vapours, which are the sulphureous acid, and have the smell of burning sulphur.

CALCAREOUS SELENITES.

12. The vitriolic acid unites with all calcareous earths and stones with heat and effervescence; but it does not saturate itself with these earths unless much weakened by water. It forms with them one kind of salt, which is always the same, whatever was the species of earth employed. This has the name of *selenites*. I add the term *calcareous*, in order to distinguish it from the selenites which has a vitrifiable earth for its basis, the properties of which are different.

By this combination the vitriolic acid loses the greatest part of its saline properties, and communicates them to the calcareous earth; and
in

in return, the earth communicates part of its properties to the acid. The neutral salt resulting from the mixture participates of the nature of both. It has scarcely more taste than calcareous earth: it dissolves easily, but in very small quantity, in water; and boiling water does not dissolve more than cold.

GYPSUM, OR PLASTER STONE.

The substances which bear this name are very abundant in nature. Those called *gypsa*, *alabaster*, and *plaster stones*, are calcareous selenites formed by nature.

These substances differ from the artificial selenites in being met with in very large masses, whereas the latter are always figured in very small crystals. When the masses are irregular, they are called *alabaster* and *plaster stone*. When they are regularly crystalised and disposed in flakes lying one above another, they are called *gypsum*.

The natural and artificial selenites are entirely of the same nature, and possess the same properties.

70 SALINE SUBSTANCES.

PREPARED GYPSUM, OR PLASTER.

When these saline substances are exposed to the fire, they lose their water of crystallization with a small noise or crackling called *decrepitation*, and become very friable, and of a very fine opake white. Gypsum during this operation is divided into extremely small plates or leaves; and when sufficiently calcined, is called *prepared gypsum or plaster*.

EFFECTS OF THE VITRIOLIC ACID UPON VITRIFIABLE EARTHS.

The vitriolic acid has no disposition to unite with vitrifiable earths when in an aggregate mass, nor even when they are divided by mechanical means. It is necessary to bring them into a state of more minute division than can be done by mechanical means in order to procure their combination with this acid. This effect is easily produced by the chemical operations of which we are presently to speak.

ALUM.

Nature offers us a great quantity of vitrifiable earth in a state of considerable division, and
already

already combined with a certain proportion of the vitriolic acid. It is in clays that this natural combination is to be found. Clays, on account of the extreme division of their particles, and the union they have already contracted with the vitriolic acid, dissolve in great part in this acid. This solution not saturated, set to evaporate, forms a salt which crystalises, and into the composition of which there enters a super-abundance of acid. This salt is perfectly similar to that known under the name of *alum*. Its crystals are flattened triangles, the three angles of which are truncated.

Thus alum is a selenites the basis of which is a vitrifiable earth, and which differs from calcareous selenites, 1. in its basis being a different earth; 2. in its having a greater quantity of water in the composition of its crystals; 3. in its taste, which is acid and very astringent; 4. in its being more soluble in water, dissolving in much greater quantity in boiling than cold water.

ALUM SATURATED WITH EARTH.

Alum further differs from calcareous selenites in a very singular property. If earth of alum be

D 3

mixed

mixed with a solution of alum, and the mixture warmed, a great quantity of this additional earth is dissolved, the solution becomes entirely saturated, and the new salt which results is in very small white crystals, flat, tacky, and very soft to the touch. This salt is scarcely at all soluble in water, is insipid, and much resembles calcareous selenites. All pure vitrifiable earths and stones dissolved in the vitriolic acid form an alum which has all the properties of a natural alum,* and especially that singular one of forming a salt which crystallises either with a superabundance of acid, or in a state of perfect neutralisation; a property which calcareous selenites do not possess.

ALUM DECOMPOSED BY CALCAREOUS EARTHS.

Calcareous earths have more affinity with the vitriolic acid than vitrifiable earths. If to a solution of alum a calcareous earth of any kind be

* If Mr. Beaumé have in any instance procured an alum from the union of vitriolic acid with a vitrifiable earth, the production must have been caused solely by his using some specimen of vitrifiable earth from which he had not taken proper care to remove all argillaceous particles. In experiments of this kind no earth should be used but what is separated from the *liquor silicum*. M.

added,

added, it dissolves, and precipitates the earth of alum.

Lime water and hard well waters, that is, those which are loaded with calcareous felenites, effect the same decomposition.

CALCINED ALUM.

Alum exposed to a moderate heat liquefies and swells considerably. In this process it only loses its water of crystallization, of which half its weight consists. There remains after the operation, a very white, light and spongy substance, called *calcined alum*.

PHLEGM OF ALUM.

If this operation be performed in a close distilling vessel, there comes over an insipid liquor, which becomes very slightly acid towards the end. This is the *phlegm of alum*.

CRYSTALLIZATION OF ALUM.

The alum, in all these operations, has not been decomposed; it has only lost its water of
D 4 crystallization.

74 SALINE SUBSTANCES.

crystalization. If it be dissolved in water and crystallised, it is recovered in the same state as at first. There separates, however, at each solution, a certain quantity of earth.

VITRIOLIC ACID EXTRACTED FROM ALUM.

For extracting the vitriolic acid from alum, a fire of the utmost violence, continued during a day and night, is necessary: and even then but a small quantity is generally procured.

The alum met with in commerce is not prepared by the method above described. It is got in the neighbourhood of Rome after the calcination of a white argillaceous stone, of which we shall speak hereafter. In this country (France) it is extracted from different, and sometimes very compound minerals.*

ON THE CRYSTALIZATION OF SALTS.

The crystalization of salts is an operation by means of which the union of saline particles dis-

* The Yorkshire alum ore is a bituminous slate of the pit-coal kind. See *Neumann's Chemistry*. J. A.

solved

these on cooling the liquor, because it contains no more than cold water can hold in solution.

The saline particles in forming crystals attract each other according to their surfaces, and according to the particular nature of these particles. There is reason to presume that this is the mode of procedure, because, if several salts are dissolved in the same water, they are confounded and intimately blended together; but, on crystallising them, the particles of the same kind assemble, and the crystals of the different salts separate and are not confounded. In the crystals of salts there enters a certain quantity of water, which is to be considered, relatively to the nature of the salts and to the crystals, under three different states.

1. *The water which is a principle of the salt,* without which the salt would not be salt, and which cannot be separated from it without destroying its nature, and decomposing it.

2. *The water of crystallization.* This does not constitute a part of the salt; it only serves to the configuration of the crystals, and may be taken away without destroying the nature of the salt,

salt, as we have remarked in the calcination of alum. The water of crystallization in salts is absolutely pure, because salts in forming, do not admit any foreign matter into the composition of their crystals.

3. *The water of solution*, or that which holds the salts dissolved. This may hold in solution saline matters foreign to the nature of the salt to be crystallised; but the process of crystallization is such, as not to permit these foreign matters to be confounded with the crystallising salt; and, as we have just observed, the crystals in forming admit only a perfectly pure water.

The crystals of these salts contain, it is true, a little of the saline matter which the water held in solution; but this is only through favour of the *water of solution*, which is still interposed between the lamina or flakes of the crystals. These foreign matters may be drawn off without disarranging the figure, or lessening the bulk of the crystals, because they are not at all combined with them. It is sufficient to put the crystals on blotting paper to drain, whereby the water of solution is pumped out from between the inter-

78 SALINE SUBSTANCES.

stices of the crystals, and absorbed. I might here relate a great number of observations on the crystallization of salts; but they do not properly belong to a work of this kind.

ON THE FIXED ALKALI.

The fixed alkali is a saline substance extracted from the ashes of vegetables. We shall here suppose it purified, and as if it were a natural product; the manner of obtaining it will be mentioned under the vegetable kingdom.

The fixed alkali is under a dry form, which shews that it has more earth in its composition than the vitriolic acid. It is colourless and inodorous. When deprived of all humidity it is white and affects no particular figure.

It has a sharp, caustic and burning taste, and leaves in the mouth a slight flavour of rotten eggs.

It turns the blue colours of vegetables green.

OIL

OIL OF TARTAR.

When the fixed alkali is very dry it unites with water with considerable heat; it strongly attracts moisture from the air, and is thereby resolved into a liquor. In this state it is commonly called *oil of tartar per deliquium*. The name of oil is improper, as the fixed alkali has nothing of an oily nature. It has been given only on account of the consistence of this liquor, which somewhat resembles that of fluid oil.

Fixed alkali has a good deal more fixity than the vitriolic acid. It is capable of supporting the most violent heat in close vessels without rising; but when it has a free communication with the air, it is entirely dissipated by the force of fire in white, very thick vapours; and it flies off still more readily when at the same time it has immediate contact with kindled phlogiston.

FIXED ALKALI RENDERED MORE CAUSTIC
BY QUICKLIME.

Fixed alkali is unable to contract any union with calcareous and vitrifiable earths by the moist way;

80 SALINE SUBSTANCES.

way; but the salino-terreous part of lime combines with it this way, and considerably augments its causticity.*

GLASS, OR CRYSTAL.

Fixed alkali, combining by fusion with calcareous and vitrifiable earths, forms with them vitreous or vitriform substances, according to the proportions made use of.

When six, seven, or even more parts of sand are used to one of alkali, the mixture, urged a long time by the utmost violence of fire, enters into fusion; the alkaline salt facilitates the fusion of the vitrifiable matter, combines with it, and communicates to it a part of its properties. The product resulting is called *glass*, and when pure and perfect, *crystal*.

* According to Dr. Black's theory, this increased causticity arises from the loss of the fixed air which rendered the alkali mild, and which is taken from it by the lime, which has a greater affinity with that substance than itself. Alkali thus rendered caustic does not effervesce with acids, because it is deprived of that air the separation of which causes the phenomena of effervescence. J. A.

LIQUOR

LIQUOR OF FLINTS.

When two or three parts of alkaline salt are added to one of vitrifiable earth, and the degree of heat is carried no further than to melt the mixture, without giving time for the alkali to evaporate, the product obtained is a vitriform mass, in which the earth is held in solution. But, as the mixture contains a great super-abundance of alkali, it preserves almost all the properties of alkaline salt: it powerfully attracts moisture from the air, and deliquesces. In this state it is called *liquor silicum*, or *liquor of flints*.

EARTH SEPARATED FROM THE LIQUOR OF FLINTS.

The vitrifiable earth in this process becomes soluble in water through the medium of the fixed alkali. If to this liquor a little vitriolic, or any other kind of acid, be added, it seizes the fixed alkali, and precipitates the earth.

ARTIFICIAL ALUM.

This earth, thus separated from the liquor of flints, is capable, on account of its extreme division,

82 SALINE SUBSTANCES.

division, of being dissolved in the vitriolic acid ; and the solution evaporated yields crystals of true alum.* This proves the identity of vitriifiable earth, argillaceous earth, and the earthy basis of common alum.

VITRIOLATED TARTAR.

Fixed alkali combines with the vitriolic acid to the point of saturation. This combination takes place with considerable heat, and, when the liquors are sufficiently concentrated, a violent effervescence accompanies it. In combining, each of these saline substances loses its peculiar properties. By evaporating the liquor till a slight pellicle appears on the surface, a salt is obtained which forms small crystals cut in a diamond point. This is named *vitriolated tartar*, *arcanum duplicatum*, or *sal de duobus*.

* If Mr. Beaumé made his *liquor silicum* in a common crucible, the production of alum is easily accounted for, because the alkali absorbs part of the argillaceous matter of which the vessel is made. If in the experiment such flint were used as may be procured from the *liquor silicum* made in an iron vessel, the result will be very different. See *Bergman*, vol. II. Diff. 13. § III. M.

We

We may remark that neither the acid nor the alkali can crystalise by themselves; that the taste of each of these substances is very strong and distinguishable, whereas the salt resulting from their combination has very little taste: it is perfectly neutral; does not alter the blue colours of vegetables; has less affinity with water than the two saline substances composing it; dissolves in it in small quantity, and does not attract moisture from the air.

DECOMPOSITION OF VITRIOLIC SALTS WITH AN EARTHY BASIS, BY MEANS OF FIXED ALKALI.

Fixed alkali decomposes all the vitriolic salts with an earthy basis; seizing the vitriolic acid by virtue of its greater affinity with it than that of calcareous and vitrifiable earths, and precipitating the earths. These earths, being washed in a sufficient quantity of water, and then examined, are found in no respect changed as to their nature, but only more divided.

The liquors remaining after these decompositions, when set to evaporate, furnish a vitriolated tartar exactly similar to that formed by the
direct

84 SALINE SUBSTANCES.

direct combination of fixed alkali with vitriolic acid.

ON SULPHUR.

Sulphur is a compound of vitriolic acid and phlogiston. When pure it is of a lemon colour; it has an odour peculiar to itself; is somewhat transparent, dry, compact, and brittle. When cast in cylindrical molds it is called *roll brimstone*.

When a piece of sulphur is held close in the hand, the heat which penetrates it occasions a dilatation within it, which causes a slight crackling, as if it were breaking in several pieces; and in fact it generally does break. This proceeds from its very electric nature.*

Air and water have no action upon sulphur. It melts with a moderate degree of heat, somewhat exceeding that of boiling water. It fixes on cooling, and forms a vast number of points like needles. Sulphur is extremely inflammable.

* The mere dilatation of so brittle a body will account for this effect without having recourse to electricity, not one of whose known phenomena can be applied with the least success to our author's hypothesis. M.

SOFT SULPHUR.

If sulphur be melted in a crucible and poured into a basin of water, it is found to have acquired a red colour, and a soft consistence like that of wax; being easily molded between the fingers, instead of being dry and brittle as at first. This effect proceeds from the water having dissolved a certain portion of acid during the process, so that the remaining sulphur contains a super-abundant quantity of phlogiston. Sulphur during the first moments of its fusion runs thin; but it thickens considerably in an instant, in which state it must be poured into water to have it soft. If it were poured before this thickening took place, it would be dry and brittle as at first.

FLOWERS OF SULPHUR.

Sulphur exposed to the fire in close vessels undergoes no kind of decomposition. It sublimes entire into the upper part of the vessel, in a kind of powder, called *flowers of sulphur*.

SPIRIT OF SULPHUR.

If a kindled body be applied to sulphur in the open air, it takes fire and emits an active, penetrating,

trating, suffocating vapour. It decomposes during this combustion; the phlogiston is dissipated, and the acid remains detached. If the vapours are collected by proper vessels, and their condensation facilitated by water reduced to steam, the product is the *volatile spirit of sulphur*, or *volatile sulphureous vitriolic acid*.

CONCENTRATED VITRIOLIC ACID, EXTRACTED
FROM SULPHUR.

This acid is watery, on account of the watery vapours employed to facilitate its condensation; but by distillation the super-abundant water is separated, and what remains in the retort is *concentrated vitriolic acid*. It has nothing of the smell of the volatile sulphureous acid.

STAHL'S SULPHUREOUS SALT.

If, by means of a proper apparatus, a linen cloth soaked in fixed alkali be exposed to the vapour of burning sulphur, the volatile spirit of the sulphur combines with the alkali, and forms a peculiar salt, which crystalises in needles. The salt is separated from the cloth by lotion
and

and crystallization, and is the *fulphureous salt* of Stahl.

DECOMPOSITION OF THE SULPHUREOUS SALT BY THE VITRIOLIC ACID.

The salt above-mentioned is a kind of vitriolated tartar, differing from the common only in having a greater quantity of phlogiston in its composition, which renders the vitriolic acid less adherent to the alkali than when pure.

When pure vitriolic acid is poured upon this salt, it immediately raises penetrating vapours, which are those of the fulphureous acid, and taking the place of this acid, forms a true vitriolated tartar.

SULPHUR DISSOLVED IN THE VITRIOLIC ACID.

The vitriolic acid has a degree of action upon sulphur, and dissolves a small quantity of it. If the acid employed on this occasion is colourless, it acquires a slight olive tinge. This forms the solution of one of the six problems I proposed in the *Gazette de Medicine*.

LIVER OF SULPHUR.

Sulphur unites with the fixed alkali both by the dry and the moist way, without suffering any decomposition. This compound has the name of *liver of sulphur*.

The proportions of this mixture when made by fusion are equal parts of each. In the moist way two or three parts of alkali to one of sulphur are employed.

MAGISTERY OF SULPHUR.

If, to liver of sulphur diffused in water, the vitriolic or any other acid be added, an effervescence is produced, an odour of rotten eggs arises, and a white precipitate is thrown down. This precipitate, washed and dried, is called *magistry of sulphur*. It is entirely the same with the sulphur before mixture, which proves that it underwent no decomposition by uniting with the alkali.

In speaking of sulphur, we observed that it is composed of the vitriolic acid and phlogiston. Hence it should follow, that by combining this
acid

acid with the phlogiston sulphur will be formed artificially. And this really happens.

ARTIFICIAL LIVER OF SULPHUR.

Vitriolated tartar is mixed with powdered charcoal and fixed alkali. The mixture is melted, and a saline reddish-brown mass is obtained, which is a true artificial liver of sulphur.

During this operation, the vitriolic acid quits its alkaline basis to unite with the phlogiston of the charcoal. The alkaline salt is added to prevent the sulphur from burning as fast as it forms. It holds the sulphur in solution, and forms an *artificial liver of sulphur*.

ARTIFICIAL SULPHUR.

This artificial liver of sulphur is dissolved in water, and the liquor filtered, which is then of a greenish hue, owing to a part of the charcoal used in the preceding operation being dissolved by the liver of sulphur. On pouring vitriolic acid into this filtered liquor, all the phenomena mentioned under the article of magistery of sulphur are observed. The precipitate resulting
is

90 SALINE SUBSTANCES.

is a true sulphur, differing in nothing from the common, except in being less white, because it is blackened by a little charcoal which falls down along with it.

VITRIOLATED TARTAR MADE WITH LIVER OF SULPHUR.

On exposing liver of sulphur to a gentle heat, the phlogiston dissipates in vapours without combustion, the vitriolic acid remains united with the alkali, and they form together a true *vitriolated tartar*.

Stahl made this experiment in order to determine the respective proportions of vitriolic acid and phlogiston which enter into the composition of sulphur; and he found that there were seven parts of acid to one of phlogiston.

PYROPHORUS.

A mixture of sugar and alum is kept over the fire in an iron pan till it emits no more fumes, and becomes dry enough to powder.

This is put into a matras, and calcined by a sand bath during half an hour; when it is taken
from

from the fire, and poured quickly into a well-stopped phial. A powder is thus produced, which has the property of taking fire when exposed to the air.

This property arises from two causes.

1. During the calcination a sulphur is formed by the combination of the vitriolic acid of the alum with the phlogiston of the sugar. Part of this sulphur burns and is dissipated during the process, forming a bluish flame, which yields the smell of burning sulphur; but a good deal remains in the pyrophorus after it is made.

2. There remains a certain quantity of alum, which does not meet with phlogiston enough to decompose it. The action of the fire calcining it more and more, its earth, from the state of extreme division in which it before was, unites in little masses, which the vitriolic acid is no longer capable of dissolving. The acid of this portion of the alum becomes therefore in some measure free, having only such a slight adhesion to the earth as to prevent its entire separation. It acquires a prodigious degree of concentration; becomes *icy*; and is distributed uniformly through
 E the

the pyrophorus. On exposure to the external air, this *icy oil of vitriol* attracts the moisture of the air, and is heated by it sufficiently to fire the sulphur.* The name of icy vitriolic acid is given to that which is concentrated so far as to appear under a concrete form, somewhat resembling ice from its solidity and transparency.

ON THE NITROUS ACID.

The nitrous acid is always in a fluid state; at least we have not hitherto been able to procure it under a concrete form. When concentrated it is of a red-orange colour. It has a strong disagreeable smell, a very sharp taste, and continually emits red vapours. Well concentrated nitrous acid is half as heavy again as water. It changes the blue colours of vegetables to red.

When let down with a certain proportion of water it usually bears the name of *aqua-fortis*.

* For the full refutation of this theory we need only refer to Mr. Bewley's excellent letter published in the *Appendix to Dr. Priestley's third vol. on Air*, where several instances are produced to shew, that pyrophori may be made, into whose composition not one particle of vitriolic acid is admitted. M.

NITROUS ACID MIXED WITH WATER.

On mixing the smoking nitrous acid with water, a considerable heat and ebullition arises, and a fine green colour, bordering upon blue, is instantly produced. This colour proceeds from the phlogiston with which this acid abounds, and which is set at liberty by means of the water, having little or no disposition to unite with it.

NITRE WITH AN EARTHY BASIS.

The nitrous acid dissolves calcareous earths with effervescence and heat. White marble may be taken for an example. If the solution is evaporated, it forms, on cooling, a saline mass in which crystals are distinguishable. This is called *nitre with an earthy basis*. It is a very deliquescent salt, powerfully attracting moisture from the air.

DECOMPOSITION OF NITRE WITH AN EARTHY BASIS BY THE VITRIOLIC ACID.

On pouring vitriolic acid into a solution of marble in the nitrous acid, a white precipitate is
E 2
thrown

thrown down, which is formed by the union of the vitriolic acid with the earth of the marble. This is a calcareous felenites, which appears under the form of a precipitate, because it cannot be held in solution by the small quantity of liquid contained in the mixture. This experiment proves that the vitriolic acid has more affinity with calcareous earths, than the nitrous.

NITRE WITH AN EARTHY BASIS DECOMPOSED BY FIXED ALKALI.

If, to a solution of white marble in the nitrous acid, fixed alkali be added, the alkali seizes on the acid, and throws down the earth. This precipitate, washed and dried, is found to be calcareous earth, unchanged in its nature, only reduced to a very fine powder.

NITRE WITH A FIXED ALKALINE BASIS.

The liquor proceeding from this decomposition, set to evaporate, furnishes needle-shaped crystals, which are called *nitre with a fixed alkaline basis*, but more commonly, simply *nitre*.

REGENERATED

REGENERATED NITRE.

Pure nitrous acid combines with fixed alkali to the point of saturation. This combination takes place with heat and effervescence. On evaporating the liquor, a true *regenerated nitre* is formed, similar to that in the preceding experiment.

The nitrous acid and the alkali on combining exhaust their properties reciprocally upon each other. The salt resulting is perfectly neutral, not changing the blue colours of vegetables either to red or green.

MINERAL CRYSTAL.

Nitre exposed to the fire melts before it becomes red hot. If, in this state, it be poured into a flat vessel, it fixes, and is then named *mineral crystal*.

NITRE ALKALISED WITHOUT ADDITION.

If nitre be kept long in fusion in a heat somewhat stronger than that employed in the pre-

96 SALINE SUBSTANCES.

ceding operation, a part of its acid evaporates. What remains in the crucible is *nitre alkalised without addition*; but the contact of the air is necessary for this effect, as it does not take place in close vessels.

NITRE FIXED BY CHARCOAL.

If, to nitre melted in a crucible, powder of charcoal be added little by little, the phlogiston of the charcoal combines with the nitrous acid, and produces a sulphur, which takes fire as soon as formed. The matter remaining in the crucible is the fixed alkali which served as a basis to the nitrous acid: it is called *nitre fixed by charcoal*. It is necessary, in order for the inflammation of the nitre to take place, either that it should be red hot, or that the phlogistic matter presented to it should be ignited: without these conditions the inflammation will not happen.

CLISSUS OF NITRE.

If this experiment be made in close vessels, the deflagration takes place as in the preceding operation, and there comes over into the receiver a great quantity of white vapours which are difficultly

ficultly condensed into a liquor. This liquor, called *cliffus of nitre*, is pure water; which proves that the nitrous acid during its inflammation was entirely destroyed. So far from being acid, the *cliffus* almost always shews marks of alkalescence; but this is accidental.

The matter remaining in the retort is fimilar to that remaining in the crucible in the preceding process.

SMOKING SPIRIT OF NITRE AFTER GLAUBER'S METHOD.

To eight ounces of powdered nitre in a retort, half its weight of concentrated vitriolic acid is added, and the mixture is distilled. The vitriolic acid disengages the nitrous acid, and unites with its fixed alkaline basis. The nitrous acid passes over in red vapours, which are condensed in the receiver in form of a red-orange-coloured liquor, that continually exhales red vapours.

This process requires several precautions, and is, in general, very difficult to manage.

The matter remaining in the retort after the distillation, is a combination of the fixed alkali

98 SALINE SUBSTANCES.

of the nitre with the vitriolic acid. When dissolved in water and set to crystalise, it yields a true *vitriolated tartar*.

Towards the close of this crystallization, a little *nitre* is procured which has escaped the action of the vitriolic acid.

NITRE DECOMPOSED BY CLAYS.

If eight or ten parts of clay be mixed with one of nitre, and the mixture distilled, a nitrous acid similar to the preceding is procured, which also is smoking when sufficiently *dephlegmated*.

After this process there remains in the retort a vitriolated tartar mixed with clay, and adhering to it with considerable force. It may be separated by boiling the mass in water, and adding a little fixed alkali.

DECOMPOSITION OF VITRIOLATED TARTAR BY PURE NITROUS ACID.

We have seen that the vitriolic acid decomposes nitre, and disengages its acid; but this is
by

by the dry way. By the moist way, the nitrous acid decomposes vitriolated tartar.

In order to effect this, about equal parts of vitriolated tartar and common nitrous acid are put into a matrafs, and the mixture heated till the salt be dissolved, which is easily done. The liquor on cooling furnishes true crystals of nitre; it is therefore certain that in this process the nitrous acid has expelled the vitriolic, and taken possession of its alkaline basis.

The cause of this decomposition is, that there enters into the composition of vitriolated tartar a certain quantity of phlogiston; and as the nitrous acid has more affinity with this principle than the vitriolic, it decomposes the vitriolated tartar through favour of the phlogiston.

It is to be remarked, that this decomposition cannot be effected by the dry way, on account of the volatility of the nitrous acid, which eludes the action of the fire, and is dissipated in vapours.

100 SALINE SUBSTANCES.

CHANGE OF COLOUR OF THE VAPOURS OF NITROUS ACID, BY MEANS OF THE VITRIOLIC ACID.

If smoking nitrous acid and vitriolic acid be mixed together, vapours arise, which instead of being red, like those of pure nitrous acid, are white.

DEPHLOGISTICATION OF VITRIOLIC ACID BY THE NITROUS ACID.

The nitrous acid, mixed in very small quantity with vitriolic acid which has been blackened by oily matters, very speedily whitens it. This effect proves the greater affinity that the nitrous acid has with oily matters and phlogiston, than the vitriolic.

SAL POLYCHREST OF GLASER.

If nitre and sulphur in powder are melted together in a crucible, the phlogiston of the sulphur attacks the nitrous acid, and produces a very brisk inflammation; and there remains in the crucible a saline mass, composed of the vitriolic acid of the sulphur, and the alkaline basis of the nitre. This salt is similar to vitriolated tartar, although
it

it bears the name of *Glafer's Sal Polychrest*. In this process all the nitrous acid is not destroyed, because there is not phlogiston enough in the sulphur. If the process be performed in close vessels, a great part of the nitrous acid is found in the receiver, mixed, however, with the vitriolic acid of the sulphur.

GUN-POWDER.

An intimate and very exact mixture of six ounces of nitre with one of sulphur and one of charcoal, produces *gun-powder*. The effects of this powder proceed from its sudden inflammation, and the great quantity of nitrous sulphur which forms as the powder fires.

DECOMPOSITION OF GUN-POWDER.

If gun-powder be boiled in water, the nitre dissolves, and one sometimes meets with those little particles of gravel which too often occasion the destruction of powder-mills. On evaporating the filtered liquor, all the nitre that was in the powder is obtained by crystallization.

After the filtration of the water there remains on the filter the sulphur and the charcoal.

E 6

These

These may be separated, either by subliming the sulphur in close vessels; or by exposing the mixt to a degree of fire capable of burning the sulphur without kindling the charcoal; which is easily done under a muffle.

FULMINATING POWDER.

A mixture of three parts of nitre, one of sulphur, and two of fixed alkali, forms a powder which has the property of detonating in the open air with a considerable explosion, when gently heated so as to liquefy it. The loud explosion of this powder also proceeds from the portion of nitrous sulphur which is formed during the liquefaction of the mixture, and which inflames as soon as it has acquired a certain degree of heat. If the heat be too weak, the nitrous sulphur flies off as fast as it is formed, and no explosion is produced.

ON THE MARINE ACID.

The marine acid is always fluid, and cannot be procured under a concrete form. It is obtained by decomposing sea-salt by means of the vitriolic acid. When well concentrated it is of
a lemon

a lemon colour. It has a very sharp taste, and a tolerably agreeable smell, approaching to that of saffron.

It turns the blue colours of vegetables red.

The most concentrated marine acid weighs nine drams and a half in an ounce measure of water.

It continually emits white vapours, which are not, however, perceived, except when they are in immediate contact with the air. These vapours occasion a sense of heat. They are very corrosive.

SEA-SALT WITH AN EARTHY BASIS.

This acid unites with calcareous earths with heat and effervescence, and forms with them deliquescent neutral salts, which crystalise only by cooling. This combination is called *sea-salt with an earthy basis*.

FEBRIFUGE SALT OF SILVIUS.

The marine acid unites with fixed alkali to the point of saturation, with heat and effervescence.

cence. From this combination results a neutral crystalisable salt, called *regenerated sea-salt*, or *febrifuge salt of Silvius*. This salt is much less agreeable than common sea-salt, from which it differs essentially in its basis; the name of regenerated sea-salt is therefore improper.

ON THE BASIS OF SEA-SALT.

The basis of sea-salt is a particular alkali, which has the name of *mineral alkali*. A great quantity of it is extracted from the ashes of marine plants, as varec, soda, &c.

CRYSTALS OF SODA.

The mineral alkali differs from the vegetable alkali already examined, in its property of crystalising like the neutral salts, which the other has not. This is owing to the greater quantity of earth which enters into its composition.

It differs further from the vegetable alkali in this; that when exposed to the air, instead of attracting moisture from it, it loses its water of crystalization, and is reduced to very fine white powder.

It

SALINE SUBSTANCES. 105

It is also somewhat less caustic than the vegetable alkali.

SOAP LYE.

Five pounds of quick-lime, and fifteen pounds of soda in powder are boiled together in a sufficient quantity of water; the liquor is filtered and evaporated till it is concentrated enough to weigh eleven drams in an ounce measure of water. This is the lye of which soap is made. The lime augments considerably the causticity of the marine alkali.*

CAUSTIC STONE.

Soap lye evaporated to dryness forms a very deliquescent alkaline salt, which melts with a moderate heat. It is cast in small plates, and then makes what is called *caustic-stone*. This is a very strong caustic, used in surgery.

REGENERATED SEA-SALT.

The marine acid unites with crystals of soda to the point of saturation with heat and efferves-

* It does this, according to Dr. Black, by robbing it of its fixed air. Soap lye will not effervesce with acids. J. A.
cence.

cence. This compound, filtered and evaporated, yields a neutral salt, which sometimes crystallises in very regular cubes, and very often in triangular prisms. The cubical crystals are formed under the liquor; the prismatical, at the surface, in contact with the air.

This salt is absolutely the same with that obtained by the evaporation of sea water, and is called *regenerated sea-salt*.

DECREPITATED SEA-SALT.

Sea-salt exposed to the fire crackles and decrepitates with violence. This effect proceeds from its water of crystallization, which, tending to fly off, bursts the crystals of the salt. When the crackling is over, it is removed from the fire. All salts which have very compact crystals, containing little water of crystallization, decrepitate in the same manner in the fire.

SMOKING MARINE ACID.

If twenty-four ounces of sea-salt, with as much concentrated vitriolic acid, and eight ounces of water, are distilled in a retort, the salt
is

is decomposed, and lets go its acid in vapours which are very difficultly condensed, and are only perceptible in the open air. This liquor collected in the receiver, is of a lemon colour. It forms the *smoking marine acid*, or *Glauber's smoking spirit of salt*.

CAPUT MORTUUM OF SMOKING SPIRIT OF SALT.

The matter remaining in the retort after the distillation of smoking spirit of salt, is dry, compact, and attracts the moisture of the air. It is formed by the combination of the vitriolic acid with the alkaline basis of sea-salt, and consequently is a true Glauber's salt. This matter always contains a good deal of sea-salt which could not be decomposed for want of moisture and the concurrence of the air.

GLAUBER'S SALT.

In order to obtain the Glauber's salt contained in this mass, it must be dissolved in water and evaporated. It furnishes large clean crystals, brilliant and transparent, in great, pretty regular needles. This is the *Glauber's salt*. Towards the end of the crystallization, a portion
of

108 SALINE SUBSTANCES.

of sea-salt which has not been decomposed by the vitriolic acid, is always found.

GLAUBER'S SALT FALLEN INTO EFFLORESCENCE.

There enters into the crystals of Glauber's salt somewhat more than half their weight of water of crystallization, which adheres to them very slightly. When this salt is exposed to the air, it loses the greatest part of this water, becomes opaque, and is converted into a white powder. In this state its nature is in no respect altered; and if redissolved and crystallised it recovers its original form.

Glauber's salt thus fallen into efflorescence is as difficult to bring into fusion as fixed alkali; but when it is in crystals it liquefies with a moderate heat, merely through favour of the great quantity of water of crystallization it contains.

SEA-SALT DECOMPOSED BY CLAY.

If ten or twelve parts of moderately dry clay are mixed with one of sea-salt, and the mixture distilled, the acid of the salt passes over into the receiver,

receiver, where it collects under form of a lemon-coloured liquor, less strong than the smoking marine acid. This is the *common spirit of salt*. What remains in the retort is a Glauber's salt composed of the alkaline basis of sea-salt, and the vitriolic acid of the clay. This salt adheres very strongly to the clay; from which it is separated by the same means that we pointed out in speaking of the residuum after the decomposition of nitre with clay.

GLAUBER'S SALT MADE BY THE DIRECT COMBINATION OF THE VITRIOLIC ACID AND THE MARINE ALKALI.

If vitriolic acid and crystals of soda (which, as we have observed, are nothing else than pure crystallised marine alkali) are combined to the point of saturation, and the mixture diluted with a sufficient quantity of water, and then set to crystallise, a Glauber's salt, similar to that we have already mentioned, will be obtained.

QUADRANGULAR NITRE.

A combination of the nitrous acid and crystals of soda dissolved in water and evaporated,
yields

110 SALINE SUBSTANCES.

yields brilliant transparent crystals, in form of cubes or lozenges, which deflagrate in the fire like common nitre. This is *quadrangular* or *cubic nitre*.

SEA-SALT.

The marine acid and crystals of soda combined to the point of saturation, yield, by crystallization, *sea-salt*.

DECOMPOSITION OF SEA-SALT BY THE NITROUS ACID.

To two ounces of sea-salt in a retort are added four ounces of nitrous acid, and the mixture is distilled. There passes into the receiver part of the nitrous acid which has not had time to decompose the sea-salt; and then vapours arise, which are spirit of salt, produced by the decomposition of the sea-salt by the nitrous acid. The two acids thus united are called *aqua regia*.

The saline mass remaining in the retort, dissolved in water and crystallised, yields quadrangular nitre.

ON BORAX.

Borax is a neutral salt of a peculiar kind, which comes to us from the East Indies, and the origin of which is not yet known. It is uncertain whether we owe this product to art or nature. The borax which is met with in quantities as an object of commerce is purified. Some is also found which has only undergone a beginning purification, and is called *rough borax*.

A prejudice has long prevailed concerning the purification of borax, that it could only be performed by peculiar methods, known only to a few persons. I was desirous of ascertaining by my own experience whether or no this opinion was well founded; and I found that borax was not more difficult to purify than any other salt. The products obtained from it during its purification throw a good deal of light on its nature.*

We

* For a full account of the origin, manufacture, and purification of borax, see *Rozier*, tom. XIV. p. 437. From the second vol. of the *Salt. D'Opsant*, p. 23, it appears that the redative salt of borax is found in the waters of Cherchiago and of another lake near Castelnovo in Italy. It has likewise been found in the electorate of Saxony, and in the neighbourhood

112 SALINE SUBSTANCES.

We shall now examine the properties of purified borax.

Borax is composed, as we shall find, of a peculiar neutral salt which supplies the place of an acid, and has been called *sedative salt*, and an alkali absolutely similar to that which is the basis of sea-salt.

The sedative salt, though perfectly neutral, acts as an acid in the borax, and neutralises the marine alkali, as if it were a real acid.

Borax has a saline neutral taste.

It turns syrup of violets green, but very slightly so.

CALCINED BORAX.

There enters into the composition of the crystals of borax about half their weight of

hood of Halberstadt, and little doubt can be entertained of its existing in other parts of Europe. Hence we have reason to expect that borax will soon be copiously produced without the necessity of travelling for it to the East Indies; for when we have the sedative salt, the compound is easily formed by the addition of the mineral alkali. M.

water

water of crystalization. When exposed to the fire, it loses this water, puffs up and swells considerably, and is changed into a white, dry, light, friable matter, called *calcined borax*.

GLASS OF BORAX.

Borax calcined and urged with a more violent fire in a crucible, enters into fusion, and is converted into a vitriform, white, transparent substance, called *glass of borax*. During this calcination and fusion the borax has lost none of its properties. By boiling in water it is totally dissolved. This solution by evaporation furnishes crystals which have exactly the same properties with the original borax. At every process, however, a small quantity of a white argillaceous earth is separated.

SEDATIVE SALT SEPARATED FROM BORAX BY
THE VITRIOLIC ACID.

If, to a solution of borax, some vitriolic acid be added, no effervescence takes place; but the liquor set to crystalise yields a white shining salt, formed in very small light scales. This is the *sedative salt* which we have mentioned as one
of

114 SALINE SUBSTANCES.

of the constituent parts of borax. Mr. Geoffroy was the first who got sedative salt by this process, which he published in the Memoirs of the Academy of Sciences.

At the end of the crystallization of sedative salt, Glauber's salt is procured, which is formed by the union of the vitriolic acid with the alkaline basis of the borax.

SEDATIVE SALT SEPARATED FROM BORAX BY THE NITROUS ACID.

A solution of borax treated with the nitrous acid affords the same phenomena as with the vitriolic. It separates in the same manner the sedative salt from the borax.

At the end of the crystallization a quadrangular nitre is procured, formed by the union of the nitrous acid with the alkaline basis of the borax.

SEDATIVE SALT SEPARATED FROM BORAX BY THE MARINE ACID.

The marine acid in like manner decomposes borax, uniting with its alkaline basis, and separating its sedative salt.

At

SALINE SUBSTANCES. 115

At the end of the cryſtalization a ſea-ſalt, not at all differing from the common, is procured.

SOLUTION OF SEDATIVE SALT.

Sedative ſalt has ſcarcely any taſte ; it does not attract the moiſture of the air, and does not change the blue colours of vegetables. It diſſolves difficultly and in ſmall quantity, in water.

GLASS OF SEDATIVE SALT.

Sedative ſalt, urged by the fire in a crucible, does not ſwell like borax. It is converted into a vitriform white, milky, and ſemitranſparent matter.

This glaſs diſſolved in water yields, by cryſtalization, ſedative ſalt the ſame as it was before. This proves, that in all theſe proceſſes the ſedative ſalt undergoes no alteration. A part of it, however, is decompoſed ; as appears from a portion of white argillaceous earth, which is ſeparated in every ſolution after its fuſion.

F

SEDATIVE

SEDATIVE SALT SUBLIMED.

Cryſtalifed ſedative ſalt, expoſed to the fire in an earthen cucurbit covered with its head, ſublimes and riſes into the head under the form of ſmall cryſtals in thin flakes, extremely light and very brilliant.

Homberg was the firſt who made ſedative ſalt by ſublimation; but this was by a very different proceſs. He mixed borax with a lye of colcothar; this mixture he diſtilled in a glaſs alembic, and raiſed the fire towards the end of the diſtillation. By this method he obtained a ſublimed ſalt, ſimilar to that which we have juſt treated of. To this he gave the names of *ſedative ſalt*, and *volatile narcotic ſalt of vitriol*.

He moiſtened a freſh the matter which remained at the bottom of the cucurbit, and proceeded to a new ſublimation; and he repeated theſe ſublimations with the ſame precautions, till no more ſalt was procured.

Homberg did not well underſtand what took place in theſe operations. He thought that the
ſalt

salt was afforded by the vitriol, and that the borax served to disengage it. But the direct contrary really happens; it is the vitriolic acid which disengages the sedative salt, and combines with the alkaline basis of the borax. Homberg, however, had remarked that when the matter was not moistened with water the salt did not sublime; wherefore he recommends a repetition of the moistening at every sublimation.

REGENERATED BORAX.

If sedative salt be combined with crystals of soda, a *regenerated borax* is produced, which in no respect differs from borax before its decomposition.

METALLIC SUBSTANCES.

METALLIC substances are the heaviest bodies in nature. There is no earth, whether calcareous or vitrifiable, which is so heavy as the lightest of these. This truth has been abundantly proved by hydrostatical experiments.

Metallic substances are always perfectly opaque; that is, they entirely oppose the passage of the light.*

* Newton, however, asserts that if gold be foliated and held between the light and the eye it will appear most evidently to transmit the blue rays. See his *Optic*, p. 11. Book I. Prop. X. M.

They

They all have a brilliancy and splendor peculiar to themselves, which chemists have termed *metallic lustre*.

Metallic substances exposed to the action of the fire, enter into fusion, and in cooling recover their former solid consistence. When suffered to cool gently after a perfect fusion, the metallic particles receive a symmetrical and regular arrangement with respect to each other, which is peculiar in every different metallic substance, and shews itself at their surface.

Chemists say that metallic substances take a convex form at their surface during fusion. This is true when they are melted in vessels made of a matter with which they cannot contract any union, as crucibles of earth, clay, &c. but it is not the same when metallic vessels are used for this purpose. For example, if lead be melted in a copper vessel, or tin in one of iron, these metals are not convex at their surface; on the contrary, a concavity is observed. This proceeds from the ascent of the edges of the melted metal along the sides of the metallic vessel; which ascent is owing to the disposition the

several metallic substances have to unite with each other.

Metallic substances are heated by warm air and water more speedily, and cool again more quickly, than any other bodies exposed to the same temperature.

It is on account of this property, that mercurial thermometers are more esteemed than those of spirit, in experiments where the transitions of heat and cold are only momentary; for mercury dilates and condenses much more readily than any other fluid we are at present acquainted with.

Mr. Richmann,* who has made many very curious experiments on this subject, observed that lead cools in the air sooner than tin, tin than iron, and iron than copper. He also remarked the different periods in which different metals exposed for some time to frost, afterwards regained the heat of the surrounding atmosphere. This he found to be in an order exactly the reverse of that of their cooling; that

* Memoirs of the Academy of Petersburg for the years 1752 and 1753.

is, lead warmed first, then tin, and so on. From these observations he concluded, that the augmentation and diminution of heat in metals, are neither in an inverse ratio to their densities, nor to the absolute cohesion of their particles, nor to their hardness, nor in a ratio compounded of these two or three ratios.

Chemists divide metallic substances into several classes, and these divisions are founded on general properties which are common to several metallic bodies. On this foundation, their first division is into *metals* and *semimetals*; and the metals are subdivided into two classes, the *perfect* and *imperfect*.

Metals are those metallic substances which besides the general properties which we have just mentioned, possess ductility and malleability, and resist the action of fire without being dissipated or volatilised.

The PERFECT METALS are *gold*, *platina*, and *silver*. They have this name on account of their undergoing the utmost violence of fire without suffering any alteration.

The IMPERFECT METALS are *copper, tin, lead,* and *iron*. These are ductile as well as the perfect metals; but they are destroyed and converted into earth by the action of fire; whence their title.

The SEMIMETALS are *regulus of antimony, bismuth, zinc, regulus of cobalt, and regulus of arsenic*.^{*} The name of semimetal is given them because they are void of ductility, are volatilised by fire, and undergo calcination like the imperfect metals.

There is another metallic substance which chemists usually range among the semimetals. This is *mercury* or *quicksilver*. We think however with Mr. Macquer, that it is better to make a separate class of it.

The imperfect metals and semimetals have one property in common, which is to emit an

* To this catalogue may be added, siderite, molybdænum, manganese, and nickel: the last of which the eminent Bergman has most decisively shewn to be a separate metal, which may be depurated from all mixtures of cobalt, arsenic, or copper, and which cannot be produced by the union of iron with any of the ingredients which are usually separated from the nickel-line ores. See vol. II. *Diff. de Nicolo*. M.

odour when rubbed, or when only warmed by the hand. This odour is different in different metals, and easily distinguished. The perfect metals and mercury alone yield none.

ON GOLD.

Gold is a perfect metal; moderately hard; of a bright yellow colour; very little elastic and sonorous. It is the heaviest of all the metallic bodies, and consequently of all the bodies in nature.

Gold acquires a sensible rigidity beneath the hammer, and is softened by *nealing*.* Its colour is variable. It is sometimes met with very high coloured, and sometimes very pale; Wallerius says that it is even found almost white.

Gold weighed by the hydrostatical balance loses between a nineteenth and twentieth of its weight in water.

It is the most ductile of all metals, and likewise the most tenacious. A gold wire of a tenth

* This is performed by heating it red hot in a furnace with charcoal, and suffering it to cool slowly; repeating the process as occasion requires. J. A.

of an inch in diameter is capable of supporting a weight of five hundred pounds without breaking.

Air and water have no action upon it.

FUSION OF GOLD.

Gold, exposed to the fire, reddens long before it melts. When just going to melt it takes a sea-green hue; but undergoes no alteration, or diminution of weight. Gold which has been well melted and suffered to cool slowly, has its surface figured in very large brilliant facets of a foliated form.

Pure acids, sulphur, and fixed alkali, have no action upon gold, either by the dry or the moist way.

SOLUTION OF GOLD IN AQUA REGIA.

A mixture of the nitrous and marine acids forms a compound acid called Aqua Regia, which dissolves gold by the assistance of heat. This solution is of a gold colour, and transparent.

CRYSTALS

CRYSTALS OF GOLD.

This solution set to evaporate and crystallise, furnishes saline crystals, called crystals of gold.

ANIMAL MATTERS STAINED BY SOLUTION OF GOLD.

Solution of gold applied to bone and ivory leaves a reddish-purple stain which does not wear out. Skins are also stained in the same manner.

GOLD PRECIPITATED FROM ITS SOLUTION BY FIXED ALKALI.

If fixed alkali be added to a solution of gold, the metal is precipitated in form of a very deep yellow powder.

GOLD IN RAGS.

Clean old linen rags are plunged into a solution of gold, and when well soaked in it, are dried and burned in a crucible. There remains a coal of linen mixed with gold in a very divided state. This powder is used, applied on the end of a phial cork, to gild delicate work which cannot be gilt in another manner.

GOLD DISSOLVED IN LIVER OF SULPHUR.

Liver of sulphur, that is, a combination of sulphur and fixed alkali, attacks gold, dissolves it, and renders it soluble in water.

GOLD PRECIPITATED FROM A SOLUTION MADE BY LIVER OF SULPHUR.

If an acid be poured on a solution of gold made by liver of sulphur, the gold and sulphur fall down at the same time. On calcining this precipitate, the sulphur burns and is dissipated, and the gold is recovered in its original form.

ON PLATINA.

Platina is a perfect metal which comes to us in small grains resembling iron filings. This metallic substance is without smell and taste, of a whitish grey colour, approaching to that of polished steel, and of a specific gravity equal to that of gold.*

* All the accurate trials make its specific gravity *less* than that of gold. See on this subject, and on the other properties of platina, a very curious paper in Dr. Lewis's *Philosophical Commerce of Arts*. J. A.

PLATINA

PLATINA EXPOSED TO THE FIRE.

Platina exposed to the greatest heat we can produce in our furnaces, undergoes no alteration or diminution of weight, and does not melt. It is not, however, unfusible. When exposed to the focus of a good burning glass it enters into real fusion. The portion melted is found to have a good deal of ductility, and a degree of specific gravity similar to that of gold.

SOLUTION OF PLATINA.

Sulphur and fixed alkali taken separately do not act upon platina; no more do the mineral acids, singly. Like gold, it is soluble only by liver of sulphur, and a mixture of the nitrous and marine acids, assisted by heat.

PRECIPITATE OF PLATINA.

If fixed alkali be added to a solution of platina in aqua regia, a precipitate of an orange yellow colour is thrown down. When no more alkali is used than is necessary for the precipitation, the precipitate is of a pale yellow.

MEANS

MEANS OF DISCOVERING WHEN GOLD IS
ALLOYED WITH PLATINA.

Platina has frequently been used to augment the bulk of gold. This deceit was difficult to detect, on account of the similarity of properties in these two metals. But chemists, in their operations on platina, soon discovered a method of detecting the smallest proportion of it mixed with gold.

On dissolving the suspected gold in aqua regia, and adding a little solution of sal ammoniac, a very fine yellow precipitate immediately falls down if it really contained platina, but no precipitation ensues if it was pure.

It may, in like manner, be discovered when platina is alloyed with gold. For this purpose, the platina must be dissolved in aqua regia, and some solution of martial vitriol added to it. If the platina was mixed with gold, a brown precipitate is immediately thrown down; but no precipitation take place if it was pure.

ON SILVER.

Silver is a perfect metal, of a brilliant white, without smell and taste. Next to gold it is the most ductile of metals. It is more elastic and sonorous than gold : it becomes more rigid under the hammer, and is in the same manner corrected by nealing : it is also harder than gold.

A silver wire one tenth of an inch in diameter supports a weight of 270 pounds before it breaks.

Silver weighed in water by the hydrostatical balance, loses between a tenth and eleventh of its weight.

Air and water have no action upon it.

Exposed to the fire, it does not melt till long after being red ; and like gold it suffers no alteration or diminution of weight in fusion. Silver well melted and then gradually cooled, shews on its surface little threads in *relievo*.

SOLUTION

SOLUTION OF SILVER IN THE NITROUS ACID.

The nitrous acid dissolves silver with much effervescence and heat. This solution is clear and colourless.

LUNAR CRYSTALS,

Solution of silver, set to evaporate, forms, on cooling, very white crystals in thin flakes, called *lunar crystals*, or *lunar nitre*. These terms are derived from the name of *Luna* given to silver, as that of *Sol* was to gold, by the old chemists.

DEFLAGRATION OF LUNAR NITRE.

This metallic salt is formed, as we have observed, by the combination of the nitrous acid and silver. The acid has sufficient adhesion to the silver to deflagrate with the phlogiston. If lunar crystals are placed upon burning coal, they melt and deflagrate like common nitre; the acid is dissipated, and the silver remains in a very thin flake on the surface of the coal. This silver has no metallic brilliancy, but on rubbing it

it with the blade of a knife it recovers its usual lustre, and has all its ductility.

LAPIS INFERNALIS.

Lunar crystals melted in a crucible, and then poured in a mold in small cylinders of the size of a quill, form a powerful caustic called *lapis infernalis* or *lunar caustic*.

PRECIPITATE OF SILVER.

If, to a solution of silver in the nitrous acid, fixed alkali be added, the silver is precipitated in form of a white powder; while the acid uniting with the alkali produces a regenerated nitre. The precipitate, though white, is without metallic brilliancy, which perhaps is owing to its extreme division.

LUNAR VITRIOL.

If vitriolic acid be added to a solution of silver in the nitrous acid, it seizes the silver, and falls down with it in form of a white powder, called *vitriol of silver*, or *lunar vitriol*. This new salt precipitates, because it is vastly less soluble in water than lunar nitre.

LUNA

LUNA CORNEA.

If, to a solution of silver in the nitrous acid, the marine acid be added, it seizes on the silver, and falls down with it in form of a thick *coagulum*, to which the name of *luna cornea* has been given. This precipitate exposed to the fire in a crucible, easily melts; and in cooling fixes into a grey yellowish mass, which has always been thought to be flexible like horn, but is not so in reality. This pretended property, however, or perhaps its colour, has acquired it the name of *luna cornea*.

ANIMAL MATTERS STAINED BY SOLUTION
OF SILVER.

Solution of silver, applied to animal matters, gives them a black stain which does not wear out. This colour proceeds from the tarnish the silver acquires from the phlogiston in being precipitated on animal substances.

PRECIPITATED AQUA FORTIS.

When it is suspected that the nitrous acid is adulterated by some other acid, it is purified by
pouring

pouring in some solution of silver. The foreign acids seize on the silver, and fall down with it; and the pure nitrous acid swimming at top is called *precipitated aqua fortis*.

SILVER REVIVED FROM LUNA CORNEA.

Luna cornea exposed to a sufficient heat in a crucible, with some alkaline salt, enters into fusion, and a knob of very pure silver is found at the bottom of the crucible. This is a method of procuring silver of the utmost purity.

SULPHURATED SILVER.

If silver be melted in a crucible, and sulphur added, this attacks the silver, combines with it, and converts it into a black spongy mass. This forms an artificial ore of silver, and is called *sulphurated silver*.

GOLD AND SILVER FOR PARTING.

A mixture is made by melting together two parts of silver and one of gold; the mass is extended under the hammer and formed into little spiral coils.

PARTING

PARTING.

One of these coils is put into a matrafs with spirit of nitre, and the vessel placed upon the fire. The acid acts immediately on the silver and dissolves it. The gold is left untouched, in the same figure that the mixture had before the operation. When withdrawn it appears of a dark colour and very porous texture. It is exposed to a gentle heat in a crucible, by which means its particles are brought together, and it recovers its solidity and colour. This process is called *nealing of parted gold*; and the gold, which is very pure, is called *parted gold*.

SILVER TARNISHED BY PHLOGISTON.

Silver, exposed to the vapour of phlogiston, or sulphur, becomes of a black or very deep brown colour. This does not happen when it is exposed to the vapour of the volatile sulphureous vitriolic acid.

SILVER PRECIPITATED BY LIVER OF SULPHUR.

If solution of silver be added to solution of liver of sulphur, the nitrous acid of the solution
of

of silver seizes the alkali of the liver of sulphur, and the silver is precipitated with the sulphur in form of a very black powder, which colour proceeds from the tarnishing of the silver by the sulphur.

ON COPPER.

From the perfect metals, we pass to the imperfect, and shall begin with copper.

Copper, named by the antient chemists *Venus*, is an imperfect metal of a yellow colour with a considerable tinge of red, brilliant, and shining where it is broke. When rubbed in the hands it exhales a disagreeable odour peculiar to itself; and has a taste not less unpleasant.

Copper is next to gold and silver in ductility and malleability. It has more elasticity and hardness than any of the other metals excepting iron; and is the most sonorous of all.

In tenacity it comes nearest to silver. A copper wire one tenth of an inch in diameter will support a weight of 299 pounds four ounces without breaking.

Weighed

Weighed in the hydrostatic balance it loses between an eighth and a ninth of its weight.

When exposed to the fire, it reddens long before it enters into fusion; its surface becomes calcined, loses part of its phlogiston, and is converted into a thin pellicle which flies off in scales when the copper cools. This is called *scales* or *calx of copper*.

When copper is brought to a white heat, it enters into fusion; and on cooling gently it takes a symmetrical arrangement, which declares itself by a peculiar lustre, and a kind of foliage on the surface.

FLOWERS OF COPPER.

If copper be too long submitted to the action of a violent fire, its phlogiston burns, and forms a beautiful violet-coloured flame, which condenses into greenish grey flowers, called *flowers of copper*. This property of copper to burn with a blue flame is used to advantage in the composition of fire-works.

GLASS OF COPPER.

That portion of copper which has lost its phlogiston in the preceding operation enters into fusion in a violent heat, and is converted into a glass of a reddish brown colour.

REDUCTION OF CALXES OF COPPER.

The calxes of copper, such as the *scales* which we have mentioned, are easily brought back to their metallic form by the addition of some phlogistic substance. For this purpose, some *black flux* and rosin is mixed with scales of copper, and a violent heat applied to bring the mixture into fusion. When the crucible is cooled, a button of copper, possessing all the properties it had before calcination, is found at the bottom.

COPPER CALCINED BY THE AIR.

Air acts upon copper, tarnishing its surface, and converting it into a green rust which is called *verdigris*.

COPPER

COPPER DESTROYED BY WATER.

Water also corrodes copper. It brings a rust on its surface, which rust dissolves in the water, and gives it a green tinge.

There is no liquor or solvent which has not an action upon copper. All rust it, and reduce it to verdigris.

SOLUTION OF COPPER IN THE VITRIOLIC ACID.

Copper is dissolved with difficulty in the vitriolic acid: the acid must be boiling, and very well concentrated, for this purpose. The solution resembles a *coagulum*. This, diluted with a large proportion of water, forms the solution of copper. It is of a fine blue. It deposits a part of the copper, which has been calcined by the acid.

VITROL OF COPPER.

The solution of copper in the vitriolic acid set to evaporate furnishes, on cooling, large rhomboidal crystals, of a beautiful blue.

This

This metallic salt on exposure to the air loses a little of its water of crystallization, and becomes tarnished on the surface. It has an acid, caustic, astringent, biting taste, and a very disagreeable metallic flavour. It is called *vitriol of copper*, *blue vitriol*, or *Cyprus Vitriol*.*

COPPER DISSOLVED IN THE NITROUS ACID.

The nitrous acid, even when cold, dissolves copper very readily, with considerable heat and effervescence. The solution exhales red vapours of the nitrous acid.† Its colour is as fine a blue as that of the preceding.

* It is commonly called in our shops *Roman Vitriol*, but that name is applied by foreign writers to the vitriol of iron. Disagreeable mistakes have arisen from a want of attention to this circumstance. J. A.

† The vapour arising from the solution of copper, and also of some other metals, in the nitrous acid, has lately been a good deal the subject of investigation under the name of *nitrous air*, in the curious experiments of Dr. Priestley. It is naturally colourless, and only becomes red when mixed with common air, which seems to produce a decomposition in it. It has a remarkable power of diminishing the volume of common air, and does this in a greater degree the purer the air is, J. A.

G

The

The solution of copper in the nitrous acid yields only a metallic salt in a *magma*, which is not susceptible of crystallization, and which strongly attracts the moisture from the air, and is resolved into a liquor.

COPPER DISSOLVED IN THE MARINE ACID.

The marine acid does not dissolve copper well, except when boiling. The solution, instead of the blue colour of the preceding, has a green hue.

This solution, set to evaporate, yields needled crystals which do not attract moisture from the air.

COPPER DISSOLVED BY AQUA REGIA.

Aqua Regia dissolves copper with almost as much ease as the nitrous acid. The colour of the solution is a blue green, of a middle hue between that made by the nitrous, and that by the marine acid.

This solution yields no saline crystals.

SILVER PRECIPITATED BY COPPER.

If a plate of copper be plunged into a solution of silver in the nitrous acid, it dissolves, and precipitates the silver in the same degree. This precipitated silver is in powder, but has all its metallic lustre.

The cause of these two effects, is, 1. That the nitrous acid not being able to hold in solution more than a determinate quantity of metallic matter, and having more affinity with copper than with silver, it lets fall the latter in order to take up the former. 2. The metallic lustre of the precipitate proceeds from the large proportion of phlogiston contained in the copper, which is transferred to the silver as fast as it precipitates, and is in sufficient quantity to give it all its usual brilliancy.

This is the method used in mints to separate silver from its solvent after the process of parting gold from silver.

COPPER PRECIPITATED BY AN ABSORBENT EARTH.

If pieces of any kind of absorbent earth are thrown into a solution of copper by any acid,

the earth dissolves and precipitates the copper. The liquor is found loaded with a salt with an earthy basis, which is different according to the different acid employed.

COPPER PRECIPITATED BY FIXED ALKALI.

Fixed alkali, by virtue of its greater affinity with acids, precipitates copper from its solution in any acid. All these precipitates are of a fine green, and serve for painting in enamel and on china.

These precipitates of copper are calxes so far deprived of their phlogiston as to be very difficult of reduction.

COPPER CALCINED BY NITRE.

If a mixture of copper filings and nitre be heated in a crucible, the phlogiston of the copper combines with the acid of the nitre, and they are consumed together with a slight deflagration. There remains in the crucible a calx of copper with the alkali of the nitre.

This method is often used by silversmiths to destroy a portion of copper with which silver
was

was too highly alloyed, and bring the silver to its proper standard.

ENS VENERIS.

If copper plates are stratified with sulphur, and calcined, the sulphur attacks the copper, and converts it into an iron-coloured, very eager and brittle matter. This is called *Ens Veneris*, or *copper calcined by sulphur*.

ON TIN.

Tin, or Jupiter, is an imperfect metal, of a whiteness approaching to that of silver, very soft, very malleable, and readily extensible under the hammer, and with little or no elasticity.

A tin wire one tenth of an inch in diameter supports a weight of forty nine pounds and a half without breaking. This metal is scarcely at all sonorous when pure.

It is the lightest of all metals. In the hydrostatic balance it loses about a seventh of its weight.

Tin, rubbed between the hands, exhales a disagreeable odour peculiar to itself, and has a

taste not less disagreeable. When bent, it makes a little crackling noise as if it were breaking.

LEAVES OF TIN.

Tin has less ductility than gold, silver, or copper; yet has enough to allow of its extension into very thin leaves.

TIN EXPOSED TO THE FIRE.

Tin, exposed to the fire, melts long before it becomes red. When melted its surface is covered with a whitish grey powder, which is a portion of it calcined and deprived of its phlogiston. This is called *calx of tin*.

PUTTY OF TIN.

On continuing the calcination for a considerable time, the calx acquires a white colour, and a good deal of hardness, and is then called *putty*. This is used for polishing glass, steel, and other hard bodies.

These calxes, mixed with phlogistic matters, and urged by the fire, are reduced into tin in its original form.

FLOWERS

FLOWERS OF TIN.

If very pure tin be exposed to a strong heat in a crucible, it calcines as in the preceding experiments; and a part sublimes into the upper part of the vessel in form of very white and brilliant needles. These are the *flowers of tin*.

RED CALX OF TIN.

When the fire has been sufficiently strong in the above process, there is found under the flowers of tin a purplish red calx, which has risen in a vegetation, and has the form and figure of cauliflowers.

GLASS OF TIN.

Beneath this calx is found a part of the calx of tin which has entered into perfect fusion, and forms a true glass of tin, pure, clean, and transparent, of a fine ruby or garnet colour. This proves, contrary to the common opinion, that calx of tin, like the greater part of other metallic calxes, is capable of entering into fusion by
 G 4 itself,

itself, and forming a real glass. I have assured myself of this fact by repeated trials.

TIN DISSOLVED BY THE VITRIOLIC ACID.

The vitriolic acid dissolves tin with scarcely any effervescence, and requires the aid of heat. A strong smell of sulphureous acid exhales during the solution, and a quantity of sulphur is even formed, which swims on the surface of the liquor. This sulphur is produced by the union of part of the phlogiston of the tin with the vitriolic acid. The solution is of a blackish colour. It deposits a good deal of calx of tin which is so far deprived of phlogiston as to be no longer soluble in the acid.

TIN CALCINED BY THE NITROUS ACID.

The nitrous acid does not so much dissolve as calcine tin. It attacks the metal with considerable violence and impetuosity, and excites a very great degree of heat and ebullition. The acid seizes with avidity upon the phlogiston of the tin, and converts it into a very white calx, insoluble in any acid, and very difficult of reduction.

SOLUTION

SOLUTION OF TIN IN THE MARINE ACID.

The marine acid is the true solvent of tin; but it must be in a concentrated state, and aided by heat. This solution exhales a very strong odour of garlic or arsenic.

As soon as the marine acid acts upon tin, it loses its lemon colour, and ceases to fume as it usually does when concentrated.

SALT OF JUPITER, OR OF TIN.

The solution of tin in the marine acid, set to evaporate, yields needled crystals which do not attract moisture from the air. They are called *Sal Jovis*.

TIN DISSOLVED IN AQUA REGIA.

Aqua Regia dissolves tin perfectly. This solution affords a great number of phenomena, the detail of which cannot be entered into here. I shall only say, that it is sometimes colourless; in other circumstances, of an amber colour;

sometimes of a dingy crimson; and sometimes is converted into a fine white transparent gelly.

PRECIPITATES OF TIN.

Absorbent earths precipitate tin from its solvent. Fixed alkali does the same. From these precipitates there result so many calxes of tin, and kinds of neutral salts, differing from each other according to the different acid which held the tin in solution.

GOLDEN PRECIPITATE OF CASSIUS.

If to a solution of tin diluted with a good deal of water, some drops of solution of gold are added, the mixture presently acquires a purple colour, and in the space of a few days a precipitate of the same colour is formed. This precipitate of gold and tin is employed in painting on enamel.

Tin, or even its vapour, instantly destroys all the ductility of gold and silver.

TIN CALCINED BY NITRE.

Tin causes nitre to deflagrate, and a brisk flame arises during the operation. The tin by
this

this process is calcined, and there remains in the crucible calx of tin with the alkali of the nitre.

SULPHURATED TIN.

Tin combines with sulphur by fusion. It becomes, by this mixture, eager and brittle, and is disposed in facets like the broken surface of Zinc.

BRONZE.

Copper and tin, melted together in suitable proportions form what is called *bronze*, or *bell-metal*.

Tin, in combining with copper, communicates to it part of its fusibility. The mixture of these two metals is of greater specific gravity than each had separately, because they mutually penetrated each other during their combination.

TINNING OF COPPER.

Tin applies very well to the surface of copper, and forms a coating which preserves it from
G 6
rust.

rust. This is the *tinning of copper*. In order, however, that the process should succeed, it is necessary that the surface of the copper should be very well and newly cleaned, and that the tin should not be calcined by the heat used in the operation. For this purpose, a good deal of rosin is mixed with the tin when melted.

ON IRON.

Iron, or Mars, is a metal of a livid white colour approaching to grey; it is the hardest, the most elastic, and next to platina, the most difficult of fusion of all the metals.

It is the only metal which has the property of striking fire either with a vitrifiable stone, or another piece of iron.

Next to gold, it is that the particles of which have the greatest tenacity. An iron wire one tenth of an inch diameter can support a weight of 450 pounds without breaking.

It loses in water by the hydrostatic balance between a seventh and an eighth of its weight.

It

It is ductile enough, when very pure, to be drawn out into threads as fine as hair, since perukes have been made of them.

It is the only known substance in nature which is attracted by the magnet, and is itself capable of becoming magnetic, and attracting other iron.

ZWELFER'S SAFFRON OF MARS.

Iron, exposed to a very violent heat, enters into fusion, but long after it has become red.

When kept in a red heat several hours without being melted, its surface calcines, and is converted into a reddish brown powder, named *Zwelfer's saffron of Mars*.

SAFFRON OF MARS PREPARED BY DEW.

The combined action of air and water rusts iron; its phlogiston is destroyed and dissipated, and there remains at length a rust, which is called *Saffron of Mars prepared by dew*. Iron in filings

filings is generally used for this purpose, as it presents a larger surface.

MARTIAL ÆTHIOPS.

Iron filings kept under water in a vessel, and agitated from time to time, is at length divided into particles of sufficient tenuity to remain a while suspended in water. Iron thus divided is called *martial æthiops*. It contains all its phlogiston, because it has had no contact with the external air. It is entirely attractible by the magnet, and completely soluble in acids.

IRON DISSOLVED BY THE VITRIOLIC ACID.

The vitriolic acid, even diluted, attacks iron with considerable impetuosity. During the process of solution, if a candle be brought to the mouth of the vessel, an inflammation is produced which causes a pretty strong explosion. This explosion is owing to the inflammation of the sulphur which is formed by the union of the vitriolic acid with the phlogiston of the iron, a great part of which is reduced to vapours, and suddenly takes fire on the approach of flame.

OCHRE.

OCHRE.

The solution of iron in the vitriolic acid deposits, when fully saturated, a yellow powder, which is a calx of iron totally deprived of phlogiston, and named *ochre*.

GREEN VITRIOL, OR GREEN COPPERAS.

On evaporating this solution, it yields green rhomboidal crystals, which are called *green vitriol*, *martial vitriol*, or *green copperas*.

This metallic salt, exposed to the air, tarnishes, loses its water of crystallization, and is reduced to a whitish powder.

VITRIOL CALCINED TO WHITENESS.

This vitriol, exposed to the fire, liquefies through favour of its water of crystallization, and is reduced to a powder of a dirty white. When its water is entirely dissipated, what remains is called *dried vitriol*, or *vitriol calcined to whiteness*.

COLCOTHAR.

COLCOTHAR.

If the calcination of martial vitriol be pushed further, a part of the vitriolic acid is dissipated in sulphureous acid; and the iron loses its phlogiston, and is calcined by the vitriolic acid. What remains in the crucible is a calx of iron of a high red colour, which still retains a large quantity of vitriolic acid, half combined with it. This substance is called *colcothar*.

A great part of the vitriolic acid in the colcothar is, as it were, in a separated state, and in a higher degree of concentration. It attracts the moisture of the air, and resolves into a liquor; but does not reunite with the iron, because this is deprived of phlogiston.

ICY VITRIOLIC ACID.

When martial vitriol newly calcined to redness is submitted to distillation with a violent heat, a vitriolic acid is procured, which is so concentrated that it congeals on cooling, and on that account is named *icy vitriolic acid*. This process is extremely laborious, and requires a
fire

fire of the utmost degree of violence, and long continued.

What remains in the retort is a colcothar which retains so much of the vitriolic acid as could not rise during the distillation on account of its too great adhesion to the earth of the iron.

SALT OF COLCOTHAR.

If colcothar be washed in water, and the liquor evaporated, it yields by crystallization a salt which has partly an earthy, and partly a ferruginous basis. It is called *salt of colcothar*.

SWEET EARTH OF VITRIOL.

The powder which remains on the filter after sufficient washings of colcothar is of a red colour like colcothar. This is a calx of iron deprived of all its phlogiston and all its acid. It is called *sweet earth of vitriol*.

SMOKING NITROUS ACID MADE WITH COLCOTHAR.

If a mixture of colcothar and nitre be distilled in a retort, a nitrous acid is obtained, extraordinarily

dinarily smoking, and of a deep red colour. Its fumes are much more red and abundant than those of Glauber's spirit of nitre above-mentioned. This process is also more difficult to conduct, and requires many precautions.

The nitrous acid made with colcothar is more smoking than the other, because it is prodigiously loaded with phlogiston. When a vitriol slightly calcined and very dry is employed in preparing it, the nitrous acid procured is so far supersaturated with phlogiston, that a part of it forms a substance which swims above the acid, and has the appearance of an oil. I have in my possession nitrous acid prepared in this manner and with this fluid on its surface, which I have kept about five years.

What remains in the retort after this distillation is a vitriolated tartar, formed by the alkali of the nitre, and the vitriolic acid of the colcothar. On dissolving the mass in water, filtering, and evaporating, crystals of genuine vitriolated tartar are obtained. There remains on the filter a calx of iron deprived of all its phlogiston. This is used to advantage for polishing glass.

IRON SEPARATED FROM MARTIAL VITRIOL
BY FIXED ALKALI.

If to a solution of iron in the vitriolic acid, fixed alkali be added, the iron is precipitated under a greenish colour, which, however, soon disappears. On drying it in the open air it acquires a reddish colour, because it is deprived of phlogiston.

This precipitate is not attractible by the magnet when dried slowly; but it is, when dried in an open vessel, on the fire. When dried in a close vessel, without the access of the air, it preserves all its phlogiston, is of a black colour, is perfectly attractible by the magnet, and entirely soluble in acids.

The liquor separated from this precipitate contains a true vitriolated tartar, formed by the combination of the vitriolic acid and fixed alkali.

IRON REVIVED WITHOUT FUSION.

If a calx of iron not attractible by the magnet be put over the fire with a little oil, or some fatty matter, it recovers the phlogiston it had lost, and acquires all the properties of iron, without the necessity of being melted. It, consequently, is iron revived without fusion. This iron, however, is very little soluble in acids, because the surface of each particle is coated with a coaly substance. Some physicians esteem this preparation a very good medicine. We are indebted for it to M. Majault, Doctor of the faculty of physic at Paris.

SAFFRON OF MARS PREPARED WITH SULPHUR.

A mixture of equal parts of sulphur and iron filings, moistened with a little water, swells, heats considerably, and, when the matters are in large quantity, actually inflames. If, after the heat and tumefaction are subsided, the fire be raised, the iron is found converted into a black earth, which is neither attractible by the magnet, nor soluble in acids.

The

The swelling and heat proceeding from this mixture are owing to the action of the sulphur upon the iron: the phlogiston of the sulphur flies off; the vitriolic acid combines with the iron, and forms a true martial vitriol, which may be separated from the mass remaining after the effervescence is over, by lotion.

Calcination dissipates a great part of the vitriolic acid that was united to the iron, and at the same time destroys the phlogiston of the iron. The ferruginous earth remaining is therefore a kind of colcothar, but which contains less vitriolic acid than common colcothar.

IRON MELTED BY SULPHUR.

To one of the ends of an iron bar heated to a white heat, a roll of brimstone is applied. Both of them drop in tears. In this process, a part of the sulphur is combined with the melted iron, and has reduced it to the state of a pyrites. This iron is in grains. It is eager and brittle, and its particles are arranged in rays like those of pyrites.

This

This operation is performed over a basin full of water, that the portion of sulphur which is not combined with the iron may be immediately extinguished, and may not incommode the operator by its fumes.

The sulphur falling into the water is figured in little drops connected by small threads, like a bunch of grapes. It is in the same state with the *soft sulphur*, mentioned *page 85*.

VITRIOL OF IRON AND COPPER.

When iron and copper mixed together are dissolved in the vitriolic acid, the solution furnishes crystals, of a beautiful green colour and a rhomboidal figure, which lose part of their water of crystallization in the open air. This is a bad quality of vitriol, and is found in that which comes from Germany.

IRON DISSOLVED IN THE NITROUS ACID.

The nitrous acid dissolves iron with a good deal of effervescence and heat. When this solution is not completely saturated, it is of a greenish

ish colour, but when perfect so, it is of a fine orange red.

IRON PRECIPITATED BY ITSELF.

When fresh iron is added to a solution of the same metal in the nitrous acid, it dissolves, and precipitates that which was before held in solution.

The cause of this is, that the fresh iron being provided with all its phlogiston, the nitrous acid seizes on it with avidity, and calcines the iron as it dissolves it, letting fall that which it before held, in proportion as it takes up this.

STAHL'S MARTIAL ALKALINE TINCTURE.

If to fixed alkali dissolved in water, a solution of iron be added, a precipitate is immediately formed, which, however, presently disappears on agitating the mixture, and dissolves in the alkali. This liquor is of a fine red colour. This experiment does not succeed well but with a solution of iron not saturated, and a very pure alkali. If the alkali contains never so little earth,

earth, the ferruginous precipitate only dissolves in very small quantity.

STAHL'S APERIENT SAFFRON OF MARS.

If an acid be poured to the alkaline tincture of Stahl, it combines with the fixed alkali, and precipitates the iron, which preserves a fine red colour.

SAFFRON OF MARS DISSOLVED IN THE NITROUS ACID.

Although this saffron of Mars has been highly calcined by the nitrous acid, it is still soluble in acids; for which reason Stahl prefers it to other martial saffrons for medicinal uses.

SOLUTION OF IRON BY THE MARINE ACID.

The marine acid dissolves iron with a good deal of facility, but with less effervescence than the other acids. This solution is somewhat greenish.

IRON

IRON DISSOLVED BY AQUA REGIA.

Aqua Regia dissolves iron with the same phenomena as those of the fore-mentioned acids.

COPPER PRECIPITATED BY IRON.

Into a solution of copper in any acid a very clean bar of iron is plunged. The iron dissolves, and in the same degree precipitates the copper, which appears with all its metallic lustre. This experiment proves that copper has less affinity with acids than iron has.

This method is used in mints to separate the copper which has served for the precipitation of silver.

IRON CALCINED BY NITRE.

A mixture of iron and nitre, exposed to the fire in a crucible, detonates, and throws out a great number of very brilliant sparks. This mixture is the basis of sparkling fireworks. The matter remaining in the crucible, washed and dried, forms a calx of iron.

H

ON

ON STEEL.

The purest iron always contains a certain portion of ferruginous earth, which is not completely metalised, and wants a sufficient proportion of phlogiston to become good iron. This earth is interposed between the very particles of the iron, acts there as a foreign body, and prevents it from having all the softness and flexibility of which very pure iron is susceptible.

In converting iron to steel, all the business consists in giving phlogiston to this ferruginous earth which is intermixed with the substance of the iron, and rendering it itself true iron. This is effected by exposing to the fire in a covered crucible iron bars along with a mixture of animal earth and powdered charcoal. The phlogiston of the coal penetrates the iron, revives its ferruginous earth into true iron, and thus makes what is called *steel*.

TEMPERING OF STEEL.

If a bar of this steel be made red hot, and then quenched in cold water, the particles of the iron
are

are fixed by the sudden cold, and have not time to arrange themselves in the manner they usually do when iron is cooled gradually.

The iron thus tempered is by so much the more hard, eager and brittle, as it was hotter when quenched. When the steel is too brittle, it is softened by rubbing it dry upon a hard body so as to heat it a little, or by warming it in hot ashes.

WHITE IRON.

If a thin and well scraped iron plate be plunged in melted tin, the surface of which is covered with suet, the iron comes out coated with tin, and is then called *white iron*. The manufacturers in this branch expose the iron well cleaned to the vapour of sal ammoniac, that the tin may apply better to its surface.

PRUSSIAN BLUE.

This is iron coloured blue by a phlogistic matter. The process by which it is made requires several previous preparations, which we shall first mention.

H 2

PHLOGIS-

PHLOGISTICATED ALKALI.

Fixed alkali and ox's blood, or some other animal matter which contains no more earth than this, are calcined together in a crucible. The vessel is kept on the fire till the matter no longer emits fumes; it is then removed, and when cooled the product is *phlogisticated alkali*, proper for making Prussian blue.

LYE OF PHLOGISTICATED ALKALI.

The alkali thus prepared is put into boiling water, to dissolve all its saline matter. The liquor is filtered, and a phlogistic alkaline lye is obtained, of an amber colour, and with a slight scent of peach blossoms when well charged with phlogistic matter.

PREPARATION OF THE BLUE.

A solution of martial vitriol, and a solution of alum are put together in a large glass, and the phlogistic alkaline lye is poured to them. An effervescence immediately arises, and a green-
ish

ish precipitate is thrown down. The liquor is filtered in order to get the precipitate by itself, which is collected and put into a glass cup.

On pouring marine acid to the precipitate thus obtained, it immediately acquires a fine blue colour. This is called the *brightening* of Prussian blue. After standing four and twenty hours it is diffused in a large quantity of water to wash off the saline particles, and then dried. This is the *Prussian blue*.

THEORY OF PRUSSIAN BLUE.

During the calcination of the fixed alkali with the blood, the alkali becomes loaded with a great quantity of phlogistic matter. All the alkali, however, is not saturated with it; a part still remains in a pure state.

The alum is not at all necessary in making Prussian blue. It only serves, by the whiteness of its earth, to diminish the intenseness of the colour; as will presently be proved.

When the phlogistic alkaline lye is mixed with the solutions of alum and martial vitriol,

H. 3

— the

168. METALLIC SUBSTANCES.

the precipitate resulting is of three kinds; 1. The earth of the alum precipitated by that portion of alkali which is not phlogistified; 2. A portion of the iron of the vitriol, not converted into Prussian blue, and which is also precipitated by the unphlogistified part of the alkali; 3. A true Prussian blue, formed by a portion of the iron of the vitriol, precipitated by the phlogistic matter contained in the alkali.

This latter precipitate does not appear of a blue colour as soon as it is formed, because it is mixed and confounded with the other above-mentioned precipitates; but it becomes sensible on the addition of the marine acid, which dissolves that portion of precipitated iron which is not converted into Prussian blue. This acid has little or no effect on the earth of the alum; and does not dissolve the least particle of the Prussian blue already formed, which is not acted upon by acids.

During this process, two decompositions and two new combinations are effected. It is therefore an example of the double affinities which we mentioned as being produced by the mixture of four bodies.

Neither

Neither the vitriolic, nor any other acid, singly, has any action on the phlogistic or colouring matter combined with the alkali; neither has iron, singly, any action on it, nor is more capable of separating it than an acid. But the united affinities of the iron and acid act together on the compound of alkali and phlogiston: the iron seizes the colouring matter, with which it forms Prussian blue: the vitriolic acid, set at liberty, combines with the fixed alkali, and forms with it a vitriolated tartar. This is the theory of Prussian blue given by M. Macquer in a paper printed among the Memoirs of the Academy. His researches on this subject, and the theory he has deduced from them, may be regarded as a master-piece in their kind.*

It follows from what we have just said, that without alum a Prussian blue may be made which shall not require *brightening*. This happens

* It is rather surprizing that the absolute necessity of some animal substance for the production of Prussian blue, did not lead M. Macquer to suspect the fallacy of his theory. Some of the first chemists at present consider Prussian blue as consisting of a phlogisticated calx of iron united with an acid which Scheele and others have procured in a separate state, and to which they give the name of the *Prussian Acid*. M.

H 4

when

when that portion of alkali which is not phlogisticated is saturated with an acid. For this curious experiment we are also indebted to M. Macquer's Memoir.

PRUSSIAN BLUE WITHOUT ALUM, WHICH DOES
NOT REQUIRE BRIGHTENING.

Some phlogistic alkaline lye is put in a glass, and an acid of any kind is dropt in till no further effervescence is produced; and the liquor is then poured on a solution of martial vitriol. A fine Prussian blue that needs no brightening is instantly formed. The cause of this is that the phlogistic lye does not now contain a superabundant alkali which may throw down a yellow precipitate of iron from the vitriol. The precipitate is now a pure Prussian blue.

DECOMPOSITION OF PRUSSIAN BLUE.

Acids have no action upon Prussian blue; but alkalies decompose it, by attacking its colouring matter. Fixed alkali loads itself with this matter to the point of saturation, and then does not act any longer on Prussian blue,
or

or affect its colour. What remains after the extraction of the blue colour is iron deprived of its colouring matter.

EXAMINATION OF ALKALI SATURATED WITH THE COLOURING MATTER OF PRUSSIAN BLUE.

This liquor has not the alkaline taste.

It does not effervesce with acids.

It does not change the blue juices of vegetables to green.

It does not precipitate the earth from salts with an earthy basis.

It precipitates iron from a solution in any acid in form of a very fine Prussian blue.

It precipitates all metallic substances from their solutions in any acid, under different colours, which are peculiar to each of them.

We are indebted to Mr. Macquer for all these experiments and discoveries concerning the nature of Prussian blue.

ON LEAD.

Lead, or *Saturn*, is an imperfect metal, of a white colour with a bluish tinge. It has a taste and smell peculiar to itself. Weighed in water it loses between an eleventh and a twelfth of its weight. A leaden wire of a tenth of an inch diameter is only capable of supporting a weight of twenty-nine pounds and a quarter without breaking.

Lead is the softest of all the metals. It is not sensibly elastic. It extends easily under the hammer, and is beat into thin leaves.

Air and water act upon lead and tarnish it. Its surface becomes covered with a whitish powder, which is nothing but the lead itself calcined by the air and water.

CALX OF LEAD.

Lead, exposed to the fire, enters into fusion long before it is red hot. When melted, its surface acquires a pellicle which is reproduced

as fast as it is taken off. This pellicle is the *calx of lead*.

MASSICOT.

Calx of lead, exposed to a red heat, is more and more calcined, acquires at first a pale yellow colour, and at length becomes of a deep *aurora yellow*. In this state it is called *Massicot*.

MINIUM.

Massicot, calcined in a reverberatory furnace with a heat not sufficient to melt it, has its colour continually heightened, and acquires at length a fine red, approaching to that of vermilion. It is then called *read lead* or *minium*.

LITHARGE.

Massicot exposed to a more intense heat suffers a semi-vitrification; its particles concrete into small thin scales which still preserve their red colour; and it then bears the name of *litharge*.

H 6

GLASS

GLASS OF LEAD.

Litharge or minium, exposed to the fire in a crucible, enter into fusion, and are converted into glass; but this glass has so much action upon earthy substances that it penetrates the crucible, and easily escapes through its pores.

To obviate this inconvenience, the calx of lead is mixed with vitrifiable earths, on which it exerts its action, facilitating their vitrification. The mixture brought into perfect fusion forms a every transparent glass, called *glass of lead*.

REDUCTION OF CALX AND GLASS OF LEAD.

All the calxes, and even glass of lead, melted in a crucible with some fatty matter, resume the phlogiston which they had lost, and are revived into lead.

SOLUTION OF LEAD IN THE NITROUS ACID.

The nitrous acid diluted with water, dissolves lead very easily. The solution is clear, limpid and colourless.

SATURNINE

SATURNINE NITRE.

The solution of lead in the nitrous acid, furnishes, on crystallization, a salt of a dead white, called *saturnine nitre*. This salt decrepitates violently, and inflames, when exposed to the fire in a crucible, without requiring the immediate contact of phlogiston. The cause of this is, that the lead, although combined with the nitrous acid, still retains a considerable portion of phlogiston; which promotes the inflammation of the nitrous acid.

VITRIOL OF LEAD.

If to a solution of lead in the nitrous acid, the vitriolic acid, or any salt containing it, (vitriolated tartar, or Glauber's salt, for example,) be added, this acid dispossesses the nitrous acid, and seizes the lead, falling down with it in form of a white powder, which is called *vitriol of lead*. This salt precipitates, because it is little soluble in water.

PLUMBUM

PLUMBUM CORNEUM.

If to a solution of lead in the nitrous acid, marine acid, or any neutral containing it, be added, a white precipitate in form of a coagulum is immediately produced. This has the name of *Plumbum Corneum*, because, when melted in a crucible, it acquires on cooling the transparency of horn. It is entirely soluble in water, and the liquor on evaporation yields little needed crystals.

MAGISTERY OF LEAD.

If to a solution of lead fixed alkali be added, it seizes on the acid, taking the place of the lead, which falls down in a white powder, named *magistry of lead*.

Some chemists assert that water by itself will precipitate lead dissolved in the nitrous acid; but this only happens when the water employed is loaded with selenites, in which case it is the vitriolic acid, and not the water, that effects the precipitation.

ARTIFICIAL

ARTIFICIAL ORE OF LEAD.

Lead and sulphur, melted together in a crucible, unite, and form a black, eager, brittle, flaky substance, which does not melt till after it is red hot. This is called *sulphurated lead*, or *artificial lead ore*.

ANOTHER COMBINATION OF SULPHUR WITH LEAD.

When sulphur in powder is thrown upon melted lead, and the mixture strongly agitated, it forms a black, somewhat scaly powder, called *plumbum ustum*, or *lead mineralised by sulphur*.

LEAD CALCINED BY NITRE.

If lead and nitre are melted together in a crucible, a small obscure detonation takes place, and the lead is reduced to a reddish calx.

WHITE ENAMEL.

A mixture of calx of lead, calx of tin, sand and alkaline salt, brought into fusion by a strong heat,

heat, forms a glass of an opaque white, which is called *enamel*.

The white colour of this kind of glass proceeds from the calx of tin, which being very refractory, and not fusible even by a violent heat, is only interposed in form of a fine powder between the particles of the glass.

CUPELLATION OF SILVER BY LEAD.

The facility with which lead is reduced to a calx or glass, causes it to be used as a medium for promoting the calcination and vitrification of the imperfect metals which happen to be mixed with gold and silver.

For example; when silver is alloyed with copper, it is melted with lead in a flat shallow crucible, made with the powder of calcined bones, which is called a *cupel*. A fire is made strong enough to calcine and vitrify the lead. In this state it vitrifies the foreign metal mixed with the silver, and causes it to be imbibed with itself by the cupel.

The

The cupel appears as if it were wet while in the furnace. During the time of the process, a rotatory motion is observed proceeding from the centre to the circumference of the melted metal. This motion ceases when there is no more lead to be calcined; and at the same instant the silver appears more brilliant and shining. This instant is called the *lightning* or *fulguration*. The cupel is then taken from the fire, and the silver in it is called *cupelled silver*.

SILVER EXTRACTED FROM LEAD.

There is very little lead which does not contain a minute portion of silver, and sometimes of gold.

To ascertain this, a certain quantity of lead is submitted to the cupel, and there remains, after every operation, from the thirtieth of a grain to a grain of the precious metals, to the ounce of lead. The Assayers of gold and silver term this product from lead the *witness*; because, in their operations, it is put into the scale on the side of the weight, in weighing cupelled silver, in order to subtract with exactness what the lead has left in cupelling the silver.

ON MERCURY.

Mercury, or *Quicksilver*, is a metallic matter always fluid, or at least not losing its fluidity without an excessive degree of cold. Although fluid, it does not wet or moisten like other liquids; it only moistens and adheres to those metals with which it is capable of uniting.

Mercury, by reason of its fluidity, forms a separate class among metallic substances. It has all their general properties, and differs from them only in respect to some of its peculiar properties.

Mercury has the whiteness and brilliancy of silver.

It admits of being divided with extreme facility. Its globules always affect a convex figure when it is not applied to some metallic substance with which it can unite. It has the metallic opacity.

When weighed in water, it loses about a thirteenth of its weight.

Mercury

Mercury seems to attract dust. When left in the open air its surface is instantly covered with the little bodies that float in the atmosphere.

On January 6, 1760, there was a cold at Petersburg which caused Reaumur's thermometer to descend about 33 degrees below the freezing point.* The opportunity of this natural cold was taken to excite a greater artificial cold; and by means of a mixture of smoking spirit of nitre, and pounded ice, which was of the temperature of the place, the thermometer was brought down to 186 degrees below the freezing point.† After this it was perceived not to vary. The thermometer was broke, and the mercury was found fixed. Several strokes of the hammer were given to its convexity, by which it was flattened like a piece of lead without splitting or cracking; but as soon as it began to lose its intense cold, it returned to its usual fluidity.‡

This

* Equal to about 60 degrees below the freezing point, or 28 below 0, of Fahrenheit's.

† Equal to about 338 below the freezing point, or 306 below 0, of Fahrenheit's.

‡ By Mr. Hutchinson's experiments, it is demonstrated, that quicksilver congeals and becomes solid at 40 below 0; and that
the

This is a very interesting discovery both with respect to Physics and Chemistry ; but still more so to Alchemy. The artists in this branch have a fine field opened for attempts to take away from mercury this superabundant central fire, (if I may use the expression) which gives it its fluidity by keeping it always in fusion.

MERCURY PRECIPITATED PER SE.

Air and water have no action upon mercury.

If it be exposed in a flat vessel to a very long continued heat, its surface calcines, and is converted into a red, shining, scaly powder, called *mercury precipitated per se*.

This operation is very tedious, lasting even for years. Only a small quantity can be put into a single vessel ; on which account it is proper to multiply them when we want to get a good deal.

the sudden contraction of the mercury at that point (which led other philosophers into an error in marking its freezing temperature) is not owing to an increase of cold proportional to that which caused its progressive contraction before it had arrived at congelation. M.

VITRIOL

VITRIOL OF MERCURY FOR MAKING
TURBITH MINERAL.

To mercury in a retort double its weight of oil of vitriol is added, and the mixture distilled. There passes over a little vitriolic acid, which is become sulphureous by combining with the phlogiston of the mercury. The saline mass remaining in the retort is crystalline and very white. It is a compound of mercury and vitriolic acid; and is called *vitriol of mercury*.

TURBITH MINERAL.

If vitriol of mercury be diffused in a large quantity of boiling water, a very heavy precipitate is immediately formed, of a fine bright yellow colour. This precipitate washed and dried bears the name of *yellow precipitate* or *turbith mineral*.

YELLOW PRECIPITATE OF MERCURY MADE
BY FIXED ALKALI.

During the lotion of the vitriol of mercury, a part of the saline mass dissolves in the water.

If

184 METALLIC SUBSTANCES.

If fixed alkali be added to this liquor it seizes the vitriolic acid which held the mercury in solution, and throws down a precipitate of a yellow colour, but a good deal paler than the preceding.

TURBITH MINERAL CRYSTALISED.

If, instead of pouring fixed alkali into the water which has washed vitriol of mercury, it be evaporated and crystalised, it furnishes a salt in little needled crystals.

MERCURY DISSOLVED IN THE NITROUS ACID.

The nitrous acid dissolves mercury with effervescence and heat. The solution is almost colourless.

MERCURIAL NITRE.

On crystalising this solution, it yields a salt figured in long needles, which melts on burning coals, much in the same manner as lunar crystals.

COPPER

COPPER WHITENED BY MERCURY.

When a piece of copper is plunged into a solution of mercury in the nitrous acid, the copper dissolves, and precipitates the mercury, which fixes upon its surface, and forms a kind of silvering, of considerable brilliancy, but not very durable.

RED PRECIPITATE.

The solution of mercury, or the salt to which we have given the name of mercurial nitre, after being dried and calcined in a matraass, loses almost all its acid. The remaining mass takes at first a yellow colour, and then a pretty deep fine red. In this state it is called *red precipitate*. This preparation always retains a certain portion of nitrous acid.

TURBITH MINERAL OBTAINED BY THE MIXTURE OF VITRIOLIC SALTS WITH A SOLUTION OF MERCURY IN THE NITROUS ACID.

If solution of mercury in the nitrous acid be poured to a solution of Glauber's salt, vitriolated tartar,

tartar, or any vitriolic salt with an earthy basis, a white precipitate is immediately produced, which, however, becomes of a very fine yellow on washing it in water.

In this experiment, two decompositions and two new combinations are effected. The nitrous acid quits the mercury to unite with the alkaline basis of the Glauber's salt or vitriolated tartar, or the earthy basis of the earthy vitriolic salts. The vitriolic acid of these salts unites with the mercury, and forms a vitriol of mercury, which precipitates, because it is soluble only in a large proportion of water. When the mixture is diffused in a small quantity of water, the precipitate is white, because the vitriolic acid is still united to the mercury. But when the precipitation is made in a large quantity of water, or the precipitate is washed, it appears of a yellow colour, because the vitriolic acid quits the mercury to unite with the water.

The liquor that swims above retains, however, a small quantity of mercury in solution. By evaporation and crystallization it yields crystals of mercurial vitriol, which are disposed in needles. These crystals, washed in a good deal of

of water, lose more and more of their acid, and furnish a turbid mineral similar to the preceding.

MERCURY PRECIPITATED FROM THE NITROUS ACID BY FIXED ALKALI.

If fixed alkali be added to a solution of mercury in the nitrous acid, the mercury is precipitated in form of a brick-dust coloured powder. The powder is washed and dried. Its red colour proceeds from the great quantity of phlogiston which the alkali contains, and which passes to the mercury.

WHITE PRECIPITATE OF MERCURY.

When marine acid, or a solution of sea-salt, is poured into a solution of mercury in the nitrous acid, a white precipitate is immediately thrown down in form of a coagulum.

This precipitate is a salt of little solubility in water, composed of the marine acid and mercury. On this occasion, the mercury quits the nitrous acid to unite with the marine, with which it has a greater affinity. If sea-salt be used instead of its acid, the nitrous acid unites

I

with

with the marine alkali, and forms with it quadrangular nitre.

CORROSIVE SUBLIMATE.

A powder composed of equal parts of martial vitriol, sea-salt, and mercurial nitre is put in a matrafs, and exposed to the heat of a sand bath. Several decompositions take place. The nitrous acid of the mercurial nitre evaporates: the vitriolic acid of the martial vitriol decomposes the sea-salt: the acid of the sea-salt attacks the mercury, and sublimes with it to the upper part of the matrafs in form of a white semi-transparent salt. This salt is in long needles when the fire has been moderate, but in a very white mass when it has been somewhat stronger. The mass, which is a compound of marine acid and mercury, is called *corrosive sublimate*, and is one of the most violent poisons.

CAPUT MORTUUM OF CORROSIVE SUBLIMATE.

There remains at the bottom of the matrafs after the sublimation of corrosive sublimate a reddish brown, very compact mass, which contains

tains the iron of the martial vitriol, and Glauber's salt.

After washing the residuum in water, the Glauber's salt is obtained by crystalization.

During the lotion, a reddish brown powder is separated, which is the iron of the vitriol deprived of all acid and phlogiston. It is of the same nature as that which we have named *sweet earth of vitriol*.

MERCURIUS DULCIS.

Corrosive sublimate is a metallic salt with a superabundance of acid : it does not attract moisture from the air ; it dissolves entirely, but difficultly, in water ; it turns red the blue juices of vegetables, which proves its having a superabundance of acid. It is in a state capable of receiving an additional quantity of mercury, which it does in the process for *mercurius dulcis*.

If four parts of corrosive sublimate are triturated with three of running mercury, the superabundant acid attacks and facilitates the extinction

tion of the mercury, and the mixture acquires a grey colour. This mixture is sublimed in the same manner as in the first operation. The product is similar to corrosive sublimate, but perfectly neutral, containing a much greater quantity of mercury. It is sublimed twice more, after which it forms what is called *mercurius dulcis*, or *aquila alba*.

MERCURIAL PANACEA.

Mercurius dulcis, pulverised and sublimed nine times more, is called *mercurial panacea*. *Mercurius dulcis* and *panacea* are much less soluble in water than corrosive sublimate. They have neither taste, nor any corrosive quality, because, in these compounds, the marine acid is perfectly saturated with mercury.

PHAGÆDENIC WATER.

If a little solution of corrosive sublimate be poured into lime water, a precipitate of a yellow colour is thrown down. This is not separated from the liquor, which is called *phagædenic water*. The precipitate is formed by the
alkaline

alkaline substance in lime water ; and it is yellow, because of a little phlogiston which the lime water contains.

CORROSIVE SUBLIMATE DECOMPOSED BY FIXED ALKALI.

If fixed alkali be added to a solution of corrosive sublimate, the mercury is precipitated in form of a brick-dust coloured powder.

ÆTHIOPS MINERAL MADE WITHOUT FIRE.

Two parts of sulphur and one of mercury, triturated together in a glass mortar, combine, and form a black powder, called *æthiops mineral*.

ÆTHIOPS MINERAL PREPARED BY FIRE.

To melted sulphur an equal weight of mercury is added: a combination between them is presently effected ; the mixture is stirred, and there results a black mass, which is afterwards reduced to powder. This is a second manner of preparing the *æthiops*. Some authors recommend setting

192 METALLIC SUBSTANCES.

ting the mixture on fire with a view of consuming part of the sulphur; but by this means a great part of the mercury is also dissipated.

ARTIFICIAL CINNABAR.

If either of the æthiops above-mentioned be exposed to the fire in a matrafs, a more intimate combination takes place; the mixture sublimes to the upper part of the vessel in form of a very deep reddish-brown mass. I have remarked that this matter requires one or two more sublimations to be made perfect *cinnabar*.

VERMILION.

Cinnabar ground upon a porphyry loses a good deal of the intenseness of its colour, and becomes of a fine scarlet. It is then used by painters under the name of *vermilion*.

MERCURY REVIVED FROM CINNABAR.

If a mixture of iron filings and cinnabar in powder be urged by the fire in a retort, the mercury

cury of the cinnabar comes over into the receiver in its original form.

There remains at the bottom of the retort, in this process, a *sulphurated iron*, formed by a combination of the iron with the sulphur of the cinnabar.

SMOKING LIQUOR OF LIBAVIUS.

Corrosive sublimate is capable of being decomposed by tin. If a mixture of these two substances be submitted to distillation, the marine acid of the corrosive sublimate quits the mercury to unite with the tin. The liquor that comes over is a very concentrated marine acid, which condenses difficultly in the receiver. It contains a little tin in solution; and emits very thick white vapours. It is called the *smoking liquor of Libavius*.

SOLID BUTTER OF TIN.

Towards the close of the distillation of the smoking liquor of Libavius, there arises to the vault of the retort a solid sublimate, composed

I 4 of

194 METALLIC SUBSTANCES.

of tin and marine acid, which does not emit fumes. This may be named *solid butter of tin*.

MERCURY REVIVED FROM CORROSIVE SUBLIMATE.

The fire employed in the foregoing process, being very gentle, is not capable of bringing over the mercury. It is found at the bottom of the retort, under its natural form, but mixed with some portions of tin, from which it may be separated, and obtained very pure by distillation.

AMALGAM OF MERCURY AND GOLD.

Mercury unites with gold with great facility, and forms with it a compound called an amalgam. This is used for the gilding called *or moulu* [*ground gold*.]

AMALGAM OF MERCURY AND SILVER.

Mercury amalgamates with silver in the same manner, and their union serves to make the silvering called *argent haché* [*minced silver*.]

AMALGAM

AMALGAM OF MERCURY AND TIN.

Mercury and tin combine in all kinds of proportions. Of this mixture, balls are made for purifying water. An amalgam of the same kind is also the matter used for silvering looking-glasses. The method of doing this, is to lay tin leaf upon a very clean piece of polished glass, placed exactly horizontally; over which mercury is poured to the height of about half an inch. The whole is left in this state for a certain time; after which one side of the glass is raised so that the greatest part of the mercury, which is not converted into an amalgam with the tin, may run off. The glass is then disposed so as to finish the draining of the mercury. The amalgam remains adherent to the glass by immediate contact.

ARBOR DIANÆ, OR THE PHILOSOPHICAL TREE.

If a small piece of amalgam of mercury and silver be put into a solution of mercury and silver mixed and diluted in water, there springs, some time after, from the amalgam, a little silver

shrub, which is not always of the same form. This vegetation is a mixed crystallization of silver and mercury, which appear with their metallic lustre.

ON REGULUS OF ANTIMONY.

Regulus of antimony is a semi-metal of a brilliant white like that of silver. It has the opacity, weight, and fusibility of metals; but it wants ductility, malleability and fixity: it consequently is of the number of the bodies that we have named *semi-metals*.

Weighed in water it loses a seventh of its weight.

It does not melt till a little time after being red-hot.

SILVERY FLOWERS OF REGULUS OF ANTIMONY.

When regulus of antimony is submitted to a violent heat in a pretty deep crucible, it is reduced to a calx. This calx becomes more and more calcined by the action of the fire, and sub-
limes

limes in needled, silvery white flowers. These are called *silvery flowers*, or, *snow of regulus of antimony*.

All the regulus is thus converted into flowers. These are soluble in boiling water, but in very small quantity, and very difficultly.

These flowers should be considered as a calx of this semi-metal. They are reducible into regulus by the addition of phlogiston.

ON ANTIMONY.

Antimony is a mineral composed of nearly equal parts of sulphur and regulus. It is seldom that this combination is made artificially, as nature furnishes it abundantly ready formed. This mineral is the ore of regulus of antimony. It is of a grey slate colour, approaching to that of lead. It is disposed in long shining needles, easy to break.

FLOWERS OF ANTIMONY.

Antimony, exposed singly to the fire in half-closed vessels, as, for example, in aludels, sub-

limes entire, and is converted into differently coloured flowers. These are what is called *flowers of antimony*. They have more or less of an emetic quality, in proportion to the degree of heat by which they have been raised. Their colour proceeds from the sulphur, which sublimes with the flowers of the reguline part.

REGULUS OF ANTIMONY, SEPARATED FROM ANTIMONY.

A mixture of antimony, tartar and nitre is thrown by spoonfuls into a crucible previously made red hot. A great detonation takes place each time. This must be suffered to cease before fresh matter is added. When the whole is put into the crucible, the fire is raised in order to bring the matter into fusion. The crucible is then taken from the fire, and broken when grown cool. A metallic button is found at the bottom, which presents a starry surface when the regulus has been well melted.

This regulus is covered with *scoriæ*, of which we shall presently take notice.

The

The nitre, in this process, detonates with the tartar and the sulphur of the antimony. The tartar, in burning, yields a coaly matter, which gives phlogiston to the regulus, and facilitates its union into a mass. The tartar and nitre, after their deflagration, furnish a fixed alkali, which dissolves a little of the sulphur of the antimony, and forms a true liver of sulphur.

This liver of sulphur holds in solution a certain quantity of regulus; and it is this mixture which forms the scoriæ that swim above the regulus. The star upon the surface of the regulus proceeds from the symmetrical arrangement which the metallic particles take during their union.

GOLDEN SULPHUR OF ANTIMONY, EXTRACTED FROM THE SCORIÆ OF REGULUS OF ANTIMONY.

The scoriæ of regulus of antimony contain, as we have already observed, liver of sulphur, which holds some regulus in solution. If this matter be boiled in water, and after filtration of the liquor, an acid of any kind be poured to it, an effervescence is produced, and an odour of rotten

rotten eggs arises, as on the precipitation of common liver of sulphur. At the same time a red precipitate is thrown down, which, after washing and drying, forms what is called *golden sulphur of antimony*.

MARTIAL REGULUS OF ANTIMONY.

Several metallic substances have a greater affinity with sulphur than regulus of antimony has; and by means of this property are very fit for separating the regulus from the sulphur. These metals are copper, tin, lead, silver, and iron; but iron is commonly made use of.

The practice then is to melt together crude antimony and points of iron nails. The iron seizes the sulphur of the antimony, and forms a mixture of less specific gravity than the regulus; which last therefore occupies the lower part of the crucible, while the scoriæ swim at top. The regulus thus procured is called *martial regulus of antimony*.

When well prepared it ought not to contain a particle of iron, and is absolutely the same with that prepared without iron.

The

The process by which the martial regulus is usually prepared, consists in adding to the iron and antimony while in fusion, a mixture of tartar and nitre. The regulus thus procured is afterwards purified by repeated fusions, but the method is tedious. By the process I have pointed out, a single fusion only is necessary, provided a sufficient degree of heat be given to melt the matter completely.*

Stahl gives the name of *succinated scorix* to those which swim above the martial regulus prepared with nitre and tartar, because their colour approaches to that of amber.

STAHL'S APERIENT ANTIMONIATED SAFERON OF MARS.

On boiling in water these succinated scorix reduced to powder, they become considerably di-

* The particular nature and advantages of Mr. Beaumé's method cannot be understood without referring to the detail in his larger work. We there find, that the fault of the common process is in adding a proportion of iron, greater than is necessary to saturate the sulphur of the antimony. The superabundant part is therefore united with the regulus of antimony. Mr. Beaumé employs no more iron than is just requisite for absorbing the sulphur, and pushes the mixture with a sudden and violent heat. J. A.

vided.

vided. The liquor is decanted after the grosser parts of the powder have subsided; these grosser parts are triturated and washed over again. The decanted liquors are united and filtered; the powder remaining on the filter is dried and detonated in a crucible with thrice its weight of nitre; the calcined matter is then washed and dried. This is *the antimoniated saffron of Mars, of Stahl*.

This preparation may be considered as iron calcined and deprived of all its phlogiston, containing a little antimony reduced to a white calx by the nitre.

PURIFICATION OF GOLD BY ANTIMONY.

This practice is founded upon that just mentioned. The sulphur of the antimony unites with the metals with which gold may be alloyed, and does not act upon the gold. A regulus of antimony is therefore formed, which precipitates with the gold, and occupies the bottom of the crucible.

The

The scorixæ which swim at top are separated, and the operation is repeated twice more, that it may be certain no foreign metals remain.

The regulus of antimony united to the gold is separated by keeping the mixture in a red heat long enough to dissipate the regulus, when the gold is left behind pure. This process cannot be performed without the loss of a little gold; a small quantity of which always remains in the scorixæ; besides that the regulus, during its dissipation, volatilises a part.

GREY CALX OF ANTIMONY.

On calcining antimony with a moderate heat, the sulphur which it contains is dissipated; and there remains a calx of the reguline part, which, on account of its greyish ash colour, is called *grey calx of antimony*.

REGULUS OF ANTIMONY MADE WITH THE CALX.

This grey calx, brought into fusion with phlogistic matters, yields a regulus of antimony.

GLASS.

GLASS OF ANTIMONY.

The grey calx of antimony, exposed singly to an intense heat in a crucible, is converted into a transparent glass, of a brown colour more or less deep. This glass is a powerful emetic.

LIVER OF ANTIMONY.

If a mixture of equal parts of nitre and crude antimony be exposed to the fire in a crucible, a strong detonation ensues, the matter enters into fusion, and, on breaking the crucible, there is found at the bottom a brown, opaque, very brilliant mass, which easily breaks. This is the *liver of antimony*.

It is covered with scoriæ almost similar to those of regulus of antimony. These are separated and thrown away as useless.

LIVER OF ANTIMONY WITHOUT ADDITION.

Liver of antimony may be made by slightly calcining crude antimony, and then melting it
in

in a crucible ; when it is turned into a vitriform mass, similar to the preceding, but of a deeper colour, and a somewhat different nature.

KERMES MINERAL, MADE BY FUSION.

If alkaline salt and crude antimony are melted together in a crucible, the sulphur of the antimony combines with the alkali, and forms a liver of sulphur, which dissolves all the reguline part of the antimony. This mixture is of a deep red colour. It dissolves entirely in a sufficient quantity of boiling water, and passes with it through filtering paper. When the liquor cools, it becomes turbid, and lets fall a red powder, which is *kermes mineral made by fusion*. It is washed and dried.

KERMES MINERAL MADE THE MOIST WAY.

Small bits of crude antimony are boiled in an alkaline lye. The sulphur combines with the fixed alkali, and dissolves a portion of the reguline part ; which makes a true *antimoniated sulphur of antimony*. The liquor while boiling is clear and transparent ; but as soon as it cools, it becomes

becomes turbid, and deposites a red powder which, washed and dried, is *kermes mineral*.

This is the common method of preparing *kermes mineral*, but the process is tedious. It is better to use antimony reduced to an impalpable powder, and throw it by small quantities into the boiling alkaline liquor. The *kermes* forms in an instant; the liquor is filtered; and the same process is repeated for the rest. After the antimony has given, by this means, all the *kermes* it is able to furnish, there remains a heavy powder, which is nothing else but that portion of regulus which is more than the liver of sulphur, formed in this process, can dissolve.

ROTROU'S SOLVENT.

Crude antimony mixed with three parts of nitre, and exposed to the fire in a crucible, loses all its phlogiston by the action of the nitre. The mixture enters into a paste-like fusion; it is then poured on a marble, pulverised, and kept in a bottle. This is *Rotrou's Solvent*.

DIAPHORETIC

DIAPHORETIC ANTIMONY.

The mass remaining on the marble is white and opaque. It attracts moisture from the air. The salts which it contains dissolve in water, and a white powder falls down, which, well washed and dried, bears the name of *diaphoretic antimony*.

ANTIMONIATED NITRE.

The liquor which has served to wash the diaphoretic antimony contains a portion of the fixed alkaline basis of nitre, proceeding from the nitre which has been decomposed by the sulphur of the antimony: it also contains vitriolated tartar, formed by the vitriolic acid of the sulphur united to the alkali of the nitre; and likewise some nitre which has not been decomposed. On evaporating this liquor, those salts are obtained by crystallization which are capable of crystallizing. The nitre thus procured is called *antimoniated* or *stibiated nitre*. There remains a liquor which yields no more crystals. This is the alkali of the nitre, charged with a certain quantity of calx of antimony held in solution.

MATERIA

MATERIA PERLATA.

If, instead of crystalising the salts contained in the liquor separated from diaphoretic antimony, an acid be poured into it, a white precipitate is formed, which is nothing else but a very refractory calx of antimony. This is called *materia perlata*, or *cerusse of antimony*. It resembles diaphoretic antimony.

REGULUS OF ANTIMONY DISSOLVED
BY AQUA REGIA.

The simple mineral acids do not dissolve antimony: aqua regia alone is capable of attacking it. If pieces of crude antimony are thrown into aqua regia, it dissolves the reguline part, but must be assisted by heat.

SULPHUR SEPARATED FROM ANTIMONY
BY AQUA REGIA.

If crude antimony reduced to a gross powder be put into aqua regia, the reguline part dissolves, and the sulphur separates and falls down under
its

its usual colour. This is absolutely similar to common sulphur.

BUTTER OF ANTIMONY.

Common marine acid does not attack regulus of antimony; but if six ounces of regulus of antimony are mixed with sixteen ounces of corrosive sublimate, and the mixture distilled in a retort with a gentle fire, the marine acid of the corrosive sublimate seizes the regulus, sublimes with it, and condenses in the receiver into a matter which crystalises on cooling. This is the *butter of antimony*.

MERCURY EXTRACTED FROM CORROSIVE SUBLIMATE AFTER THE DISTILLATION OF BUTTER OF ANTIMONY.

The mercury of the corrosive sublimate is set free after the distillation of the butter of antimony. It remains at the bottom of the retort, because it is less volatile than the butter of antimony; but, on raising the fire sufficiently, it is brought over in its turn. After the distillation of the mercury, there is found, in the retort, a button of regulus of antimony, which is the
portion

210 METALLIC SUBSTANCES.

portion exceeding that which is taken up by the marine acid.

CINNABAR OF ANTIMONY.

If, instead of employing regulus of antimony for the preparation of the butter, one part of crude antimony and two of corrosive sublimate be used, the butter is equally obtained, but the mercury is not set free as in the preceding process; it is united to the sulphur of the antimony. On augmenting the fire, a compound of mercury and sulphur sublimes to the neck of the retort, which is called *cinnabar of antimony*.

POWDER OF ALGAROTH.

Butter of antimony attracts the moisture of the air, and resolves into a liquor. If it be diluted in a large quantity of water, a white powder precipitates, which is washed and dried. This powder is the reguline part of the antimony deprived of all acid and almost all its phlogiston. A small portion of phlogiston which it still contains ought to be considered as the cause of its emetic quality, and not a pretended portion

brisk effervescence, accompanied by a great quantity of red vapours, ensues. The solution is of an amber colour. It remains clear during some time, and then forms a solution of regulus of antimony in aqua regia; but by degrees the nitrous acid acts upon the phlogiston of the reguline part, calcines it, and it precipitates in a few days under the form of a white powder.

BEZOAR MINERAL.

A mixture of butter of antimony and nitrous acid is evaporated in a sand heat, till nothing remains but a white powder. It is calcined three times successively, adding each time some nitrous acid, in order to deprive it entirely of marine acid and phlogiston. The product is called *bezoar mineral*.

ON BISMUTH.

Bismuth is a white semi-metal, with a yellowish tinge, eager, brittle, moderately hard. Its broken surface presents facets nearly resembling those of regulus of antimony.

Weighed

METALLIC SUBSTANCES. 213

Weighed in water, it loses a tenth of its weight.

Air and water have no action upon it.

It easily melts. When vitrified, it is imbibed into the pores of the cupel, and may serve, as well as lead, to purify the perfect metals by the process of cupelation. Exposed to the fire in close vessels, it sublimes entire, without losing any of its properties.

SOLUTION OF BISMUTH IN THE NITROUS ACID.

The nitrous acid has a considerable action upon bismuth. It dissolves it with a brisk effervescence and considerable heat. The solution is of a dirty crimson.

CRYSTALS OF BISMUTH.

This solution, set to evaporate and crystallise, yields a very shining white salt, but which easily loses this quality when exposed to phlogistic vapours.

MAGISTRY OF BISMUTH.

The solution of bismuth, diluted with water, lets fall the bismuth in form of a very fine white powder, which is the *magistry of bismuth*. The nitrous acid leaves the semi-metal to unite with the water. This precipitate, washed and dried, is the *Spanish white*.

ON ZINC.

Zinc is a white semi-metal, with a cast of blue, almost malleable, and very difficult to break, because it has a degree of ductility. Weighed in water it loses a seventh of its weight.

FLOWERS OF ZINC.

Zinc, exposed to a strong heat, enters into fusion at the same time that it becomes red. When thoroughly penetrated by the fire, it inflames. Its flame is lively, bright, and yellowish. During its inflammation a great quantity of white, snowy, very light flakes escape from it, and rise above the crucible. These are
called

called *philosophical wool*, *pompholix*, or *flowers of zinc*.

Flowers of zinc, although they rise in this manner, are not volatile. They are to be considered as the calx of this semi-metal. This calx is very refractory, and in the highest degree fixed.

ZINC DISSOLVED IN THE VITRIOLIC ACID.

The vitriolic acid dissolves zinc with considerable effervescence. The solution has little colour. Set to evaporate, it furnishes shining, transparent crystals, nearly resembling those of Glauber's salt. These have the name of *vitriol of zinc*, *white vitriol*, or *white copperas*.

PURIFIED ZINC.

Sulphur does not combine with zinc; it serves as a medium for its purification. When it is suspected that zinc is alloyed with other metals, it is melted with sulphur, when the sulphur unites with the foreign metals which have an affinity with it, and the zinc is found separate at the bottom of the crucible.

BRASS.

Copper, melted with zinc, loses its red and acquires a yellow colour, without losing much of its ductility. This forms a compound metal, named *brass* or *latten*.

SIMILOR TOMBAC, OR PRINCE'S METAL.

Different proportions of zinc and copper give mixtures of deeper or paler colours, approaching to that of gold. These form the compounds called *pinchbeck*, *Prince Rupert's metal*, or *similor*.

ON ARSENIC.

Arsenic is the calx of a semi-metal. It is in a white, crystalline, brilliant, transparent mass, but soon becoming opaque, yet without losing its whiteness. Weighed in water it loses a fifth of its weight. It has some properties in common with salts.

ARSENIC

ARSENIC DISSOLVED IN WATER.

Arsenic dissolves in almost all oily, spirituous, and watery liquors.

Its solution in water, on evaporation, yields red and irregular crystals.

REGULUS OF ARSENIC.

Arsenic, exposed to the fire in close vessels, sublimes entire, and preserves its whiteness. It combines easily with phlogistic matters; and in that state sublimes in a scaly, brilliant, friable substance, which has the metallic opacity, weight and lustre. This substance is called *regulus of arsenic*.

Regulus of arsenic is heavier than arsenic. It loses an eighth of its weight in water.

EFFECT OF THE MINERAL ACIDS ON ARSENIC.

The mineral acids attack arsenic, or its regulus; but they make a bad solution.

ORPIMENT.

Sulphur combines with arsenic; and from their union there results a semi-transparent, very weighty mass, of a yellow or red colour according to the proportion of sulphur.

RED ORPIMENT, REAGAL, OR REALGAR.

If the proportion of sulphur to arsenic be augmented, there results a red, shining, brittle substance, named *reagal*, or *risgal*.

DECOMPOSITION OF NITRE BY ARSENIC.

If a mixture of equal parts of nitre and arsenic be distilled in a retort, the nitrous acid passes over in red vapours and condenses. It carries over a little arsenic along with it, which gives it a smell of garlic.

NEUTRAL ARSENICAL SALT.

The saline mass remaining in the retort is formed by the combination of the arsenic with the alkaline basis of the nitre. This substance dissolves

dissolves entirely in water, and yields crystals of a regular form, which Mr. Macquer first observed, and named *neutral arsenical salt*.

NITRE ALKALISED BY ARSENIC IN THE OPEN AIR.

If nitre and arsenic mixed are thrown together into a red hot crucible, a small detonation ensues, and the nitrous acid evaporates. The saline matter remaining in the crucible attracts the moisture of the air, and dissolves in water, but does not crystalise like that in the preceding process.

SILVER PRECIPITATED BY NEUTRAL ARSENICAL SALT.

If solution of arsenical salt be poured into solution of silver, this metal precipitates as it unites with the arsenic. This precipitate is of a brick-dust colour.

WHITE TOMBAC.

A mixture of copper and arsenic, melted together in a crucible, gives a compound metal, which is eager, brittle, and of a white colour. This is *white Tombac*.

K 5

MIXTURE

MIXTURE OF ARSENIC AND TIN.

Arsenic renders all metals eager and brittle. When melted with tin, it gives it a good deal of stiffness and hardness, and the tin is disposed in facets, like regulus of antimony. It is of an extremely brilliant silvery white.

After having thus examined each substance in particular, and in their state of purity, we shall next examine the more compound minerals, beginning with those which furnish the saline mineral substances.

ON PYRITES.

Pyrites are bodies composed of a great quantity of sulphur, a very small portion of metallic matter, a greater or less quantity of argillaceous earth, and a little calcareous earth. There are pyrites which, besides these substances, contain a greater or less proportion of arsenic.

All pyrites appear to be formed by a kind of crystallization; and, for the most part, have symmetrical figures. Some Naturalists have
given

given the name of *marcasites* to those pyrites which are regularly crystalised; but these distinctions are too little essential to deserve regard. We consider as pyrites all minerals which have the general properties above-mentioned, and which are composed of the substances we have enumerated.

The figure of pyrites varies remarkably. There are some, globular, hemispherical, oblong, in clusters, in cakes, quadrangular, in regular cubes, in hexahedras, in rhomboids, in octahedras, &c.

The colour of pyrites varies less than their figures. There are some, brown, reddish, white and shining like silver; which last always contain arsenic. Others are of a fine black, which takes a beautiful polish; these are sometimes used for making buttons.

Pyrites are hard or tender. The first emit fire freely when struck against steel: the sparks are brisk, shining, and exhale a strong smell of burning sulphur.

PYRITES FALLEN INTO EFFLORESCENCE.

All pyrites fall into efflorescence, and are reduced into powder, when exposed alternately to air and moisture. Those which are very hard, undergo this change with difficulty; but their efflorescence is hastened by calcining them a little, and then moistening them with water, when they fall into powder.

VITRIOL EXTRACTED FROM PYRITES.

During the above process, the sulphur of the pyrites decomposes, the phlogiston is dissipated, and the vitriolic acid, set free, dissolves the metallic and earthy matters contained in the pyrites. This acid, united to metallic substances, forms so many vitriols, which are named from the metal that serves them for a basis. Thus when the pyrite contains iron, it forms *martial vitriol*; when it contains copper, it forms *vitriol of copper*. These are the only two metals which are mineralised in pyrites; and it is almost always these two species of vitriols which pyrites furnish.

ALUM EXTRACTED FROM PYRITES.

A part of the vitriolic acid of the pyrites unites with the argillaceous earth which they contain, and forms alum.

SELENITES EXTRACTED FROM PYRITES.

When pyrites contain calcareous earth, a part of the vitriolic acid combines with this earth, and forms selenites.

Arfenical pyrites are not usually worked for their arsenic, because this substance is occasionally got from minerals which furnish metallic matters.

FLOWERS OF SULPHUR.

Pyrites which have not fallen into efflorescence, distilled in a retort with a strong heat, yield flowers of sulphur, which sublime to the vault of the retort.

The *caput mortuum* remaining in the retort is called *burnings of sulphur*.

ROLL

ROLL SULPHUR.

In works in the great, the sulphur got by the distillation of pyrites is melted, and cast into wooden moulds, where it fixes. During its fixing it takes the crystalline arrangement observed in the inside of rolls of brimstone, which is that of needles going from the centre to the circumference.

ON ORES.

What are called *ores* are mineral substances, in which metals are mineralised always by sulphur or arsenic, and most frequently by both together. Gold must be excepted, which is never mineralised in mines, but only dispersed through the *gangue*; platina is, perhaps, another exception.

The gangue, or matrix, is the stony matter, crystallised or uncrystallised, calcareous or vitrifiable, which does not mineralise the metal, but is only interposed between the metallic particles, whether mineralised or not.

ORES* OF GOLD.

Gold is found in the bowels of the earth under an infinite number of different forms; but, as we have just observed, it is never mineralised by sulphur or arsenic like the other metals; it is only dispersed in earthy matters, without being combined: thus it is always in a *virgin* state. When alloyed, it is commonly with metallic matters, such as silver, copper, iron and lead. Peru contains the richest gold mines hitherto discovered.

Many rivers wash down little particles of gold. These are such as flow through beds of gold ore.

ORES OF SILVER.

Unmineralised virgin silver is often met with in the bowels of the earth, under a great variety of forms. Some is in grains, some has a resemblance of lace, of hair, of feathers, &c. But silver is usually mineralised by sulphur and arsenic, and often by both together.

* The term *ore* is here improperly used, according to the preceding definition of it. J. A.

There

There are very few ores of silver, properly so called, that is, which do not contain other metals. Silver is most frequently found in lead ores; and some of these are even called silver ores by the workmen, because the profit upon the silver is greater than upon the lead, although the product, in quantity, of the latter is greatest. But chemists distinguish ores by the name of the metal which they yield in greatest abundance, without regard to the value of metals. Thus, for example, when the weight of lead extracted from an ore exceeds that of silver, they call it a *lead ore containing silver*; and so of the rest.

ORES OF LEAD.

Virgin lead is very rare; lead is almost always mineralised, like silver. Lead ores are generally formed in cubes heaped upon one another, and presenting very large facets.

Lead ores in very small cubes usually contain more silver than the former.

There are many varieties of lead ore.

ORES OF COPPER.

Copper is pretty frequently met with in a virgin state, but it is most commonly mineralised. It is often mixed and confounded with other ores. Copper ores are easily distinguished, because they have always somewhat of a blue colour on their surface, which is owing to a portion of the copper calcined and reduced to verdigris.

ORES OF TIN.

Virgin tin is very rare; it is even doubted whether it is ever met with. Tin is always mineralised by sulphur and arsenic, and is seldom mixed with other metallic substances.

ORES OF IRON.

Virgin iron is not uncommon; but it is very seldom met with perfectly pure, and possessing the same properties with wrought iron. It is always impure and eager.

Iron

Iron ores are pretty generally of a brown or yellowish colour, and almost always rusted on their surface.

ORES OF ZINC.

Ores of zinc are less numerous than other ores. The true ore of zinc is *lapis calaminaris*. Zinc is found mixed with several other ores, particularly those of iron, whence it is extracted in very great quantity in the neighbourhood of Goslar.

ORES OF BISMUTH.

Ores of bismuth a good deal resemble those of lead. They are, like them, disposed in facets; but have a yellowish cast. Ores of bismuth are frequently mixed with cobalt.

ORES OF ANTIMONY.

Ores of antimony are common. They are disposed in needles or little cubes. These ores are mixed with a good deal of sulphur, and sometimes with arsenic. They often contain other metals, as gold, silver, and lead.

In

In 1748, virgin regulus of antimony was found for the first time, in Sweden.

ORES OF MERCURY.

Virgin mercury is not uncommon. It is sometimes found running; sometimes mixed with earths, without being mineralised.

Mercury is usually mineralised by sulphur. These mercurial ores are of a more or less vivid red colour; they bear the name of *native cinnabar*. This cinnabar is sometimes mixed with arsenical matters.

ORES OF COBALT.

Ores of cobalt resemble those of antimony. Their surface is almost always covered with an efflorescence of a dingy scarlet.

These ores contain a good deal of arsenic, and it is from them that arsenic is usually got. They also frequently contain a portion of bismuth. Those which contain cobalt alone are very rare.

Cobalt

Cobalt mines bring in a considerable revenue to Saxony, where the ores are worked with a good deal of intelligence. We shall give a brief account of the processes.

ARSENIC EXTRACTED FROM COBALT ORE.

Cobalt ore is pounded, and exposed to be calcined or torrefied in a furnace. During this operation it emits a great quantity of white smoke, which is condensed in a very large horizontal chimney, placed on one side of the furnace. These vapours, in condensing, form a hard, half vitrified, semi-transparent mass, white in certain spots, called *arsenic*.

REAGAL.

In other parts of the same chimney, these condensed vapours are of a yellow or red colour, which proceeds from the greater or less proportion of sulphur with which the arsenic is combined. The yellower part is called *yellow reagal*; the redder, *red reagal*.

CALCINATION

CALCINATION OF COBALT ORE.

Cobalt ore which has been torrefied in the fire, has lost all the sulphur and arsenic it contained. When it ceases to fume, it is removed from the fire; and is then called *calcined cobalt ore*.

ZAFFRE.

Ore of cobalt thus torrefied, reduced to powder, and mixed with twice its weight of flints or quartz also powdered, forms the substance named zaffre. This is much used in painting blue on porcelain or delft ware.

AZURE BLUE.

Zaffre, mixed with fixed alkali, and brought into fusion by an intense heat, is charged into a glass of a very deep blue. This is reduced to powder by means of an iron pestle, and distributed in commerce under the name of *azure*, *enamel blue*, *azure blue*, &c.

SPEISS.

SPEISS.

During the fusion of the blue glass above-mentioned, a substance separates which is only half vitrified, and precipitates under the glass. This has the name of *speiss*. It is a compound of arsenic, of bismuth in grains, of regulus of cobalt also in grains, and of a certain portion of the ore itself, which has not been able to vitrify completely, for want of being sufficiently calcined. Great care is taken to separate the speiss from the vitrified matter, because it spoils its colour.

REGULUS OF COBALT EXTRACTED FROM ITS ORE.

If calcined cobalt ore be mixed with alkaline and phlogistic matters, and the mixture exposed to a heat sufficient to melt it, the metallic part subsides to the bottom of the crucible, and scoriæ swim above it.

BISMUTH EXTRACTED FROM COBALT ORE.

When a heat of sufficient intenseness is given to the above mixture, the button of metal at the
bottom

bottom of the crucible is separated into two parts, which are easily distinguished. The upper part is the true cobalt; the lower bismuth.

These two semi-metals, though mixed and confounded in the gross mineral, have no disposition to unite; on the contrary, they separate from each other during the fusion of the ore, and arrange themselves according to the order of their specific gravity; the bismuth, as the heaviest, occupying the lowest place.

ON REGULUS OF COBALT.

Regulus of cobalt is a semi-metal of a silvery white, very brilliant when newly produced, but soon tarnishing in the air.

When well melted, its surface, like that of regulus of antimony, presents a symmetrical arrangement of chased work, as if done with the graver.

This regulus is eager, brittle, of a moderate hardness, nearly the same with that of regulus of antimony.

Weighed

234 METALLIC SUBSTANCES.

Weighed in water it loses an eighth of its weight.

It becomes red in the fire long before it melts. To bring it into fusion a degree of heat is requisite as strong as that for melting copper.

It is volatilised by an intense heat; but has vastly more fixity than any of the other semi-metals.

CALX OF REGULUS OF COBALT.

When exposed to a more moderate fire and to the open air, it calcines like the imperfect metals, and is reduced to a blackish calx.

BLUE GLASS.

This calx of cobalt vitrifies with vitrifiable matters, and forms beautiful blue glasses. Cobalt is the only substance at present known, which has the property of furnishing a very fine blue, that is not changed by the most intense heat.

REGULUS

REGULUS OF COBALT COMBINED WITH
LIVER OF SULPHUR.

Regulus of cobalt is incapable of contracting directly any union with sulphur, but by the medium of a fixed alkali it unites with it so intimately, as not to be separable except by solution in acids.

A KIND OF DECOMPOSITION OF REGULUS
OF COBALT.

I melted together in a crucible, cobalt ore, alkaline salt, gypsum, and rosin. By this process I obtained the metallic matter furnished by this ore in two different states. 1. The greatest part was combined with the liver of sulphur formed during the fusion, and swam above the scoriæ. This kind of regulus of cobalt is of a bronze colour, with large facets like bismuth. 2. At the bottom of the crucible was found a semi-metallic, white, silvery regulus, a solution of which in the nitrous acid had a slight blue tinge. It did not form a sympathetic ink with the marine acid, nor give a blue on vitri-

L fication

fication like common regulus of cobalt.* This resolves one of the six problems which I proposed in the *Gazette de Medicine*, and of which no solution has been given.

REGULUS OF COBALT CALCINED BY NITRE.

Regulus of cobalt and nitre, mixed and exposed to the fire in a crucible, detonate slightly, after which the regulus remains calcined and mixed with the alkali of the nitre. This mass is washed in water, and the liquor filtered. The powder remaining on the paper is a calx of cobalt.

REGULUS OF COBALT DISSOLVED BY THE VITRIOLIC ACID.

The vitriolic acid acts upon cobalt with difficulty. The solution is made in a retort, and the process carried on as if for distillation. It is of a deep reddish colour.

* It is this second kind of regulus which Mr. Beaumé suspects to be the *nickel* which is treated of as a new semi-metal by Cronstedt, and has ever since been usually added to the number. J. A.

SOLUTION

SOLUTION OF REGULUS OF COBALT IN THE
NITROUS ACID.

The nitrous acid attacks regulus of cobalt with impetuosity. The colour of the solution is a dingy crimson.

COBALTIC NITRE.

If a solution of cobalt in the nitrous acid be evaporated, it yields olive coloured crystals, which are deliquescent, and melt with the smallest degree of heat.

COBALT PRECIPITATED FROM THE NITROUS
ACID BY FIXED ALKALI.

If a fixed alkali be added to solution of cobalt in the nitrous acid, the metal precipitates under the form of a powder of a purplish colour. This precipitate, washed and dried, and afterwards exposed to a vitrifying heat with fusible matters, gives a very fine blue.

COBALT DISSOLVED IN THE MARINE ACID.

The marine acid acts difficultly upon regulus of cobalt. In order to effect a solution it is necessary to use a distilling apparatus, and to return the acid upon the regulus. This solution appears of a pale green colour when cold, and a fine sea green when hot. It makes a true *sympathetic ink of cobalt*.

COBALT DISSOLVED IN AQUA REGIA.

Regulus of cobalt dissolves easily in aqua regia. The solution is clear, and of a peach-blossom colour. It also makes a sympathetic ink, but only in consequence of the marine acid of the aqua regia.

SYMPATHETIC INK OF COBALT.

If a solution of cobalt in aqua regia be diluted with about four times its weight of soft water, and this liquor used to write with instead of ink, on good paper, the writing does not appear till the paper is warmed, when the traces of the pen are visible under a fine sea-green colour. This
colour

colour disappears as the paper cools, and is renewed on warming it again; and thus alternately vanishes and re-appears for an indeterminate number of times.

It is very difficult to explain the cause of this phenomenon. The disappearance of the colour does not proceed, as has been asserted, from the moisture which it attracts during the cooling of the paper; since, if a paper written upon with this ink be exposed to the vapour of boiling water in a close vessel, the characters become visible as readily as if a dry heat had been employed. Further, if such a paper be enclosed in a well-corked bottle, either dry or moist, and the bottle be heated by plunging it in boiling water, the writing appears and disappears in the same manner as when heated in the common way.

- In fine, I have made a still more decisive experiment than those above-mentioned. I plunged a paper impregnated with this liquor in boiling water: it instantly took the colour proper to it in a heated state. It must, however, be observed, that this colour is only momentary, as the boiling water dissolves and carries away the sympathetic ink from the paper.

Another phenomenon, not less difficult of explanation, is the singular property which regulus of cobalt has, not to form this sympathetic ink except with the marine acid, or this acid in conjunction with the nitrous. Solutions of cobalt in the vitriolic and nitrous acids separately, or these acids in conjunction, or mixed solutions of the separate acids, do not form the sympathetic ink. But if to each of these solutions marine acid be added, the liquor immediately acquires the property of giving a sea-green colour by the assistance of heat.

It is then to the marine acid alone that this property is due; and it is the solution of cobalt in this acid only which yields this kind of sympathetic ink, the traces of which on paper appear more vivid and deep without the mixture of nitrous acid. On the other hand, when made by the marine acid singly, it has the inconvenience of being less durable; the colour growing fainter every time the paper is warmed, and vanishing entirely after a certain period, which does not happen when the nitrous acid is added. All these phenomena appear to me very difficult of solution.

EARTHY SUBSTANCES.

THE greater part of Naturalists have thrown a good deal of obscurity on the nature of stones and earths, because they have attended more to the external figure of these substances, in their attempts to class them, than to their true specific characters. Since chemistry has occupied itself with this object, it has greatly elucidated this part of natural history. Mr. Pott is one of the chemists who has laboured most in this matter. He divides earthy substances into four species; the *vitriifiable*, *argillaceous*, *gypseous*, and *calcareous*.

Before Mr. Pott, Stahl had admitted two kinds of earth only. The numerous experiments I have made on this subject will serve to confirm

the opinion of Stahl, and to prove that there are only two species of earths, the *vitriifiable* and *calcareous*.*

Upon the foundation of these experiments, I think myself authorised to advance that argillaceous earth is only a very divided vitriifiable earth, combined with the vitriolic acid, and reduced to a saline state.

Gypseous earth is only a calcareous earth combined with the same acid, and likewise reduced to a saline state. These two substances, clay and gypsum, consequently are not pure earths, but salts with an earthy basis, formed by nature. We shall first examine the properties of these four substances separately; and then their effects with respect to each other.

ON VITRIFIABLE EARTHS.

Vitriifiable earths are the heaviest and hardest of the simple earths. They are either in

* Mr. Bergman, whose mineralogical authority at present is superior to all other, has divided the simple earths into five, viz. 1. The calcareous: 2. The argillaceous: 3. Magnesia, or the Muriatic: 4. Terra Ponderosa, or the Barytic earth: And 5. The siliceous, or vitriifiable earth, M.

regular

regular crystalised masses, or in irregular un-crystalised ones. They are also found in dust of different fineness, when they bear the name of sand.

Vitrifiable earths are not acted upon by acids or alkalies in the moist way :* they are all hard enough to strike fire with steel : they do not imbibe moisture from air or water : exposed to the most intense fire they do not enter into fusion ; their particles only conglomerate a little, without having consistence.

ON CLAYS.

I consider clays, as I have above remarked, as vitrifiable earths in a very divided state, and combined with a good deal of vitriolic acid. These earths are sometimes white ; but are also found of all sorts of colours. The purest clays are those which are whitest.

Clays diffuse themselves in water : they adhere to the tongue ; are soft to the touch ; have

* Vitrifiable earth is soluble in an acid which has been lately discovered, and which Bergman and Scheele have named the *fluor acid*. M.

a good deal of cohesion, and are easily formed by the wheel. When not perfectly dry, and exposed too suddenly to the fire, they crack with a loud explosion, and are reduced into powder. When mixed with water, and formed into a soft paste, they swell by the fire, instead of cracking. They grow hard in the fire, acquire a good deal of body and solidity, and become capable of striking fire with steel.

These earths, exposed to an intense heat, do not enter into fusion when pure. They partly dissolve in acids, and with the vitriolic acid form true alum; but by the moist way they are not acted upon by alkalies. They all contain vitriolic acid, on which account it is that they decompose nitre and sea-salt; but I have remarked that they are not all equally furnished with this acid, those which are perfectly white containing less than the others.

ON CALCAREOUS EARTHS.

Calcareous earths are the lightest of all the earthy bodies. All the species of it which are not formed by crystallization imbibe water when plunged into it, and thereby become considerably
heavier

heavier than before. They are soluble in acids, are all very tender, and are worn by friction against hard bodies. Exposed to an intense heat, they do not enter into fusion, but are converted into quicklime.

ON GYPSUM.

What chemists name gypseous earth, is a true vitriolic salt with an earthy basis formed by nature.

It is found in irregular uncrytallised masses, such, for example, as gypseous alabaster, and plaster stone. Crytallised masses are also met with, such as common gypsum. These substances being composed of calcareous earth and vitriolic acid, ought to be considered as of the same nature with what is called selenites.

The crystals of gypsum are formed by a great number of flakes, extremely small, and applied upon each other. Their figure is a very acute angle, terminated at the base by a returning angle.

L 6.

These

These substances are tender, and easy to be scratched. When exposed to a fire capable only of making them red, they lose their water of crystallization, and become opaque and friable; but when calcined by a stronger heat, the calcareous earth they contain is reduced to quicklime. In this state, if they are pulverised and mixed with water, they form a paste which hardens as they recover the water which they had lost by calcination, and makes what is called *plaster*.

Gypseous earths exposed to an extremely intense heat do not enter into fusion, but lose a great part of the vitriolic acid which they contained, and then approach nearer to the character of quicklime. This forms what the workmen call *burnt plaster*.

Gypseous earths before their calcination are not acted upon by acids; they dissolve in water, in greater quantity only, but without undergoing any alteration. If they are boiled with fixed alkali, this salt seizes upon the vitriolic acid which they contain, forming a vitriolated tartar, and the remaining earth is now no more than a pure calcareous earth.

Gypsum

Gypsum dissolves in water, but in very small quantity ; and it is this which spoils the well water of Paris, and of all the countries which abound in plaster-stone.

The four kinds of earth, the general properties of which we have thus enumerated, are absolutely unfusible by the strongest heat we can produce, when taken singly ; but when combined two by two, there are mixtures which enter into fusion, and are converted into a clear transparent glass.

A mixture of vitrifiable earth and chalk, of vitrifiable earth and gypsum, of vitrifiable earth and clay, and of chalk and gypsum, does not enter into fusion.

FUSION OF EARTHS BY ONE ANOTHER.

Clay and chalk, and clay and gypsum, melt one another, and form a glass which is hard enough to strike fire with steel.

This curious phenomenon was discovered by Mr. Pott, but no explanation of it is given by this able chemist. When I treat fundamentally
on

on this subject, I propose to demonstrate that this fusibility ought to be attributed to the calcareous earth which is reduced to quicklime during the process. The saline alkaline matter which forms during this calcination, becomes the flux of the vitrifiable earth, obliges it to enter into fusion, and occasions at the same time the vitrification of that portion of calcareous earth which has not become saline. The vitriolic acid contained in the clay and gypsum further facilitates this reciprocal fusibility.

STONE-WARE.

A mixture of crude and of baked clay, reduced to a fine powder, and diluted with water to the consistence of a paste, forms a mass capable of being turned by the wheel, and figured into vessels of various shapes. These vessels dried and afterwards baked in a very strong heat acquire a considerable hardness, on account of which property they have acquired the name of *stone-ware*.

In some places stone-ware is made with crude clay that is somewhat sandy. Vessels of this kind are as good as those made with the above-mentioned mixture.

DELFT

DELFT-WARE.

Common clay, mixed with sand and diluted with water, may be turned by the wheel like the preceding mixture; and being afterwards baked with a moderate heat, it forms the *biscuit* for delft-ware. These pieces of biscuit are covered with a coating of white enamel, made with vitrescent matters and calx of tin. The pieces are put a second time into the fire in order to melt the coating, which applies itself completely over the biscuit. It then makes *delft-ware*.

GLAZED EARTH.

The pottery called glazed earth is made of a biscuit similar to that for delft-ware, but instead of a coating of enamel, it has one of calx of lead. The pieces are put into the fire in order to melt this coating, which thus forms a glass of lead, that applies itself to the biscuit. This forms the *glazed earth*, which is the kind of pottery most in use for the table.*

* The elegant pottery called *Queen's ware* is of this kind. Its biscuit is composed of tobacco-pipe clay and ground flints. J. A.

ON PORCELAIN.

Porcelain [or china] is a semi-vitrified matter, made with clay and vitrifiable earths. Fine porcelain ought to have a perfectly white semi-transparency. Its body should be very white; of a shining grain; a little granulated, and not smooth like glass, on its broken surface; and of hardness sufficient to strike fire with steel, as well as a flint.

The coating of porcelain is a crystal glass. This should be hard, perfectly clean and transparent, and applied very uniformly upon the porcelain.

MATERIALS OF FURNACES OF BAKED EARTH.

Furnaces for chemical purposes are also made with clay and sand. Some workmen instead of sand make use of stone ware reduced to a gross powder, which answers better.

GLASS OF WINE BOTTLES.

Vitrifiable earth mixed with alkaline salts and a small quantity of calcareous earth, forms the mixture which is the basis of bottle glass. The metallic calxes which are commonly met with in the materials used in the composition of this kind of glass, are the cause of the colour met with in all wine bottles. The glass of Seve is coloured by a little iron. In some manufactories a very small quantity of azure blue is mixed with the glass in fusion, in order to give it a more agreeable colour.

GLASS ACTED UPON BY ACIDS.

If too great a quantity of calcareous earth be admitted into the composition of glass, it preserves part of the properties of this species of earth. This forms a bad kind of glass, which is acted upon by the mineral acids. The wine bottles which come from Lorraine have this defect.

REAUMUR'S PORCELAIN.

Common bottle glass cemented with gypsum in powder, and made red hot, loses a good deal of its transparency. It becomes of a milky white, and has a degree of transparency nearly the same with that of porcelain.

I attribute this change to the action of the vitriolic acid of the gypsum, which attacks the calcareous earth of the glass, and causes its particles to take another arrangement.

It is remarked that the broken surface of this glass is disposed in threads, instead of being smooth and united. This glass resists the fire nearly as well as glazed earth, and may serve for the same purposes in warming water quickly. We are indebted for this discovery to the late Mr. Reaumur.

WHITE GLASS, OR CRYSTAL.

The most beautiful glasses are those made with sand and fixed alkalies, both very pure.
The

The longer they remain in a state of fusion, and the less alkali they contain, the harder, whiter and more solid they are. This forms the fine glass known by the name of *crystal*; into the composition of which calxes of lead are also sometimes admitted, which vitrify during the fusion, and give solidity to these kinds of glass.

FALSE TOPAZ.

A mixture of sand and ceruss, urged with an intense heat, and kept a long time in fusion, forms a glass of lead, which is very hard, transparent, and of a yellow colour resembling topaz when a little phlogiston remains in it, but colourless when the phlogiston is all consumed.

S T R A S.

A yellow glass of lead, mixed with a sufficient quantity of white crystal glass, forms a less coloured, pretty hard glass, which is sold under the name of *stras*.

FALSE

FALSE RUBIES AND GARNETS.

All sorts of colours are given to stas by means of metallic calxes. The calx of gold, known under the name of *purple powder of Cassius*, gives it a lively red colour, and forms *false rubies* and *garnets*.

FALSE EMERALDS.

Calx of copper gives a green tinge to stas, and forms *false emeralds*.

FALSE HYACINTHS.

The different saffrons of Mars give red or aurora colours, more or less deep, according to the degree of calcination. This forms the *false hyacinths*.

FALSE SAPPHIRE.

The calxes of cobalt, especially that which is precipitated from the nitrous acid by fixed alkali,

alkali, communicates to stras a fine blue colour, indestructible in the fire, and forms the *false sapphire*.

FALSE AMETHYST.

Calxes of gold and cobalt mixed, give to glass a beautiful violet tinge, and form the *false amethyst*.

FALSE OPAL AND VENETIAN GIRASOLE.

If a small quantity of calx of tin be added to the composition of stras, it forms a brilliant, but somewhat opaque glass. This is what, according to the proportions of the calx of tin, makes the *false opal*, and the *Venetian girasole*.

WHITE ENAMEL.

Calx of tin, *minium* and sand, mixed and melted together by an intense fire, form a white, opaque, milky mass, known under the name of *enamel*. It is this enamel which forms the coating of delft-ware.

COLOURED

COLOURED ENAMELS.

All sorts of colours may be given to enamel by means of the metallic calxes above-mentioned; by augmenting or diminishing the doses of which, varieties of all kinds are produced.

O N

MINERAL AND SALT-WATERS, AND ON NITRE.

ON MINERAL WATERS.

THE purest water that is found in the bowels, or on the surface of the earth, is always loaded either with a little earth in a divided state which it holds in solution, or with felenitic matters. When the water contains only a small quantity of these substances, it is not rendered unfit for drinking or culinary uses.

When water in its course meets with veins of mineral matters which it is capable of dissolving, it loads itself with a certain quantity of
them,

them, and acquires taste, colour, and often odour. It is then called a *mineral water*.

Some mineral waters are warm, when they have the name of *thermal waters*.

Some are cold; that is, are constantly some degrees colder than the temperature of the place where they are found.

Lastly, some are neither hot nor cold.

The metallic matters most commonly met with in mineral waters, are iron and copper. Other metallic substances are very rarely contained in them; and there are no instances of gold and silver being found in any mineral water, although this is not absolutely impossible.

Among the saline matters that are found in mineral waters, the vitriolic acid is always that which is met with in greatest quantity, and next the marine acid: the nitrous acid is scarcely ever contained in them. These acids, in general, are not in a detached state in mineral waters, but almost always combined with the metallic

tallic matters above-mentioned. They are likewise combined with earths both of the vitri-fiable and calcareous kind, and form so many species of salts with an earthy basis.

Neutral salts with a fixed alkaline basis are also very frequently contained in mineral waters ; such as vitriolated tartar, Glauber's salt, and sea-salt. Nitre is rarely met with, and always in small quantity.

There are some mineral waters, the acids of which are not perfectly saturated, and which have an acidulous taste. They are called, on this account, *acidulous mineral waters*.*

Other mineral waters have the common fixed alkali, or the marine alkali, for one of their predominant principles. These waters, by means of their alkali, hold oily matters in solution. They are saponaceous, and lather like soap suds. For this reason they are called *saponaceous mineral waters*.

* It has since been sufficiently proved, that the acidulous taste of these waters is owing to the gas or fixed air with which they are impregnated. J. A.

Sulphur is one of the principles of mineral waters. It is held in solution in them, several different ways.

1. By division only. When these waters are exposed to the air, their sulphur precipitates almost totally, after a certain time, in form of a white powder.

2. When sulphur is contained in the acidulous waters it is in a better state of solution, and is therefore much longer in separating from them when they are exposed to the air.

3. In saponaceous mineral waters this substance is present in form of liver of sulphur. These mineral waters have an odour of rotten eggs, which acids render still more sensible.

Certain mineral waters contain a volatile principle which appears of a spirituous nature. This principle is named *gas*. Experiments have shewn that this is only air intimately mixed with the water.* This gives to certain waters which are charged with mineral matters the pungent odour and taste of sparkling Champagne

* Not the common or atmospherical air, but fixable or mephitic air, J. A.

wine. These mineral waters froth, sparkle, and if shaken too briskly, break the bottles. They inebriate like Champagne, but this effect is only momentary.

These general facts are all that we can mention in a work like this. It would take up too much room to enter into details in order to shew how the principles contained in mineral waters are united to each other. We shall also excuse ourselves from giving the details of their analyses.

ON SEA-WATER, AND THE WATER OF SALT PITS AND SPRINGS.

The salt waters of which we are now to speak, all contain a little detached uncombined earth; a little calcareous felenites; a good deal of sea salt which is used for salting provisions; marine salt with an earthy basis; and Glauber's salt.

The practices employed with respect to all these waters, have for their purpose the extraction of the sea-salt separate from all foreign matters. This is effected in different manners.

The methods used at different salt works are somewhat different, although tending to the same purpose: they turn upon certain circumstances which cannot be entered upon at present. We shall only speak of one of these methods, because all these waters may be treated in the same manner in order to obtain their sea-salt.

SCHLOT.

The brine is evaporated in large iron pans. At the beginning of the evaporation the detached earth and the selenites separate and precipitate; and the selenites carries with it a great quantity of Glauber's salt. This precipitate forms a matter which has an earthy appearance, and is called *schlot* or *scratch* by the workmen. It is separated with a good deal of care, because it injures the goodness and purity of the salt.

SEA-SALT.

When no more *schlot* precipitates, the surface of the liquor, when the evaporation is carried to a certain point, is seen covered with a great number of little crystals of sea-salt. The evaporation

poration is continued by a strong fire when the sea-salt is wanted only in very small crystals; but it is managed slowly when large crystals are to be procured. These are taken off as fast as they form, and set to drain.

There remains at last a large quantity of liquor which refuses to yield any crystals. These liquors are called by chemists *mother-waters*; but that we are now speaking of is called *bittern* in the salt works. Sea-salt crystalises in cubes and triangular pyramids.

BITTERN.

The bittern, or mother-water of sea-salt, contains a great quantity of sea-salt with an earthy basis, and a little Glauber's salt.

MAGNESIA OF SEA-SALT.

On pouring fixed alkali into bittern, a white earthy precipitate is immediately thrown down, which is the *magnesia* of sea-salt. The alkali unites with the marine acid which held the earth in solution, and forms with it a regenerated sea-

M 3. salt.

salt. Towards the end of the crystallizations the Glauber's salt which was contained in the bittern is procured.

SCALES.

During the evaporation of salt waters, a part of the schlot adheres to the bottom of the pan, along with a good deal of sea-salt with an earthy basis, a little common salt, and a good deal of Glauber's salt. All these substances are mixed and confounded. They are from time to time separated from the bottom of the pans with chissels. These are called *scales* by the workmen.

GLAUBER'S SALT PROCURED FROM SCHLOT.

The schlot is lixiviated with a good deal of cold water, in which the Glauber's salt, as being very soluble, dissolves. By evaporation and crystallization large crystals of Glauber's salt are obtained.

EPSOM SALT.

When the crystallization of the Glauber's salt is interrupted by agitating the liquor when the crystals are about to form, it yields only small irregular crystals, which bear the name of *Epsom salt*.

Glauber's and Epsom salt are therefore absolutely one and the same salt, since they contain the same principles, and the former may be made with the latter. For this purpose, nothing more need be done than dissolving the Epsom salt, and re-crystallising it. On the other hand, by interrupting the crystallization of Glauber's salt, Epsom salt may be made. This is all the difference between the two salts.*

* This is only true with respect to the salt called *Epsom salt* in France. That which goes under this name (and also that of *sal catharticus amarus*) in England, and which is obtained from the bittern of sea-salt, differs from Glauber's salt in having for its basis the earth so well known in medicine under the name of *magnesia*; whereas that of Glauber's salt is the fossil alkali. The acid of both is the vitriolic. The addition of fixed alkali serves at once to distinguish the Epsom from the Glauber's salt; occasioning a copious precipitation with the former, but producing no change with the latter. J. A.

OBSERVATIONS ON SEA-SALT.

Before we quit the subject of sea-salt, it may be proper to make some further observations upon it, and on the matters which are contained in the waters which furnish it.

1. The crystals of sea-salt are always figured in cubes or triangular pyramids.

Those which are cubical, are formed in the interior part of the liquor, where the air has no access. These crystals represent one cube en-chased within another. That which forms the centre is of a milky white, and almost opaque; it is a mass of a vast number of small cubes, heaped upon one another. The great cube is formed of saline laminæ or layers, transparent, incumbent one upon another. They are as it were separated by diagonal lines, which terminate at each angle of the little central cube.

The crystals which are triangular, have been formed at the surface of the liquor.

2. Sea-salt

2. Sea-salt is a perfect neutral, which cannot be decomposed by the action of fire. Some persons, however, suppose the contrary. They imagine that it suffers a part of its acid to escape when distilled *per se*, or when calcined in the open air, as is done in some salt works, in order to form the large masses called *loaves of salt*. It is true that common sea-salt exhales a portion of marine acid when exposed to the action of the fire, but this acid proceeds from the decomposition of the sea-salt with an earthy basis, from which common salt is never free; and not from the sea-salt with an alkaline basis. Those chemists who have supposed that common salt was decomposed by the action of the fire, have entirely overlooked the existence of this sea-salt with an earthy basis, which is mixed in more or less quantity with all the different kinds of salt in common use. I have several times made these experiments on sea-salt perfectly freed from this earthy salt, and it never yielded an atom of acid, to whatsoever degree of heat it was exposed.

3. The sea-salt with an earthy basis, although it crystalises with difficulty, yet mixes in crystallization along with that which has an alkaline basis, and is even the cause why cubical crystals

are obtained vastly larger than when the sea-salt is very pure.

SEA-SALT PURIFIED.

Common sea-salt is dissolved in water, the liquor filtered, and crystals of soda added, a few at a time. These unite to the acid of the sea-salt with an earthy basis, and precipitate its absorbent earth. When the precipitation ceases no more is added; the liquor is filtered, evaporated, and crystalised. The sea-salt obtained by this method is of the most perfect purity, and does not give out any acid by the action of fire, without a medium.

ON SCHLOT.

The schlot separated from brines in salt works, contains the selenites, and almost all the Glauber's salt. This last, though very soluble in water, nevertheless precipitates with the selenites during the evaporation; which proceeds from the great affinity which selenites, Glauber's salt, and sea-salt with an earthy basis have to each other.

ON NITRE.

Nitre, or *saltpetre* is a salt extracted from old rubbish.* In this rubbish is contained a good deal of nitre with an earthy basis, and sea-salt. In order to procure nitre with a fixed alkaline basis, the following method is practised.

NITRE EXTRACTED FROM RUBBISH.

The rubbish of old plaster is reduced to a gross powder, and lixiviated with cold water. The liquor is passed through fresh wood ashes, and then evaporated to a pellicle. During this process a great quantity of sea-salt is precipitated, which is taken away as useless. When the liquor is sufficiently evaporated, it is carried into a cool place to crystalise. The crystals that form are called *nitre of the first boiling*. This is produced from the combination of the fixed alkali of the ashes with the nitrous acid. The

* Nitre is also got from the common soil, or vegetable mould, impregnated with putrefactive substances, and exposed to the air. J. A.

alkali disengages the earth of the nitre with an earthy basis, and takes its place.

MOTHER-WATER OF NITRE.

There remains, after the crystalization of the nitre, a thick liquor which refuses to yield any crystals. This liquor consists of nitre and sea-salt with earthy basis, and is called *mother-water*.

MAGNESIA ALBA.

On pouring fixed alkali into the mother-water of nitre, there falls down a white earthy precipitate, which, washed and dried, forms the *magnesia* to which the name of *nitrous panacea* has been given.

In this operation, the alkali unites with the acids; and after the precipitation, there is found in the liquor regenerated nitre and sea-salt, which are extracted by evaporation and crystalization.

NITRE OF TWO BOILINGS.

The ashes through which the lye of the rubbish is passed, furnish a fixed alkali, which decomposes a part of the sea-salt and of the nitre with earthy bases.

We have remarked that a large quantity of sea-salt is separated, which precipitates during the evaporation of the liquor. There still remains, however, a good deal, which crystalises indistinguishably with the nitre.

This nitre of the first boiling is dissolved in a small quantity of water. The nitre is more soluble than the sea-salt, dissolves the first, and in the greatest quantity. The undissolved sea-salt is separated, and the liquor evaporated. It yields a nitre purer than the former, since it is freed from the greatest part of its sea-salt: it still, however, contains some. This is called *nitre of two boilings*.

NITRE OF THREE BOILINGS, OR REFINED.
SALTPETRE.

The process above-mentioned is repeated on the nitre of the second boiling. The saltpetre is now procured in a vastly purer state, and without any sea-salt, when the operation has been well conducted. It is called *purified or refined nitre*, or *nitre of three boilings*. Among the nitre crystalised in great works there are very often met with large beautiful crystals of nitre, in long needles, which the workmen call *nitre in sticks*.

Nitre of three boilings is sufficiently pure for gunpowder, and for the other uses to which it is applied in the arts; but for medical purposes it is made to undergo another purification.

O N T H E

VEGETABLE KINGDOM.

VEGETABLES are organised bodies, which extract from the earth the juices proper to their nature. Vegetable substances are much more compound than mineral. Their analysis is consequently more difficult : certain principles, of too great tenuity or volatility, escape us entirely.

The action of menstrua, of fire, and of the other means used for the analysis of vegetable substances, often produce such considerable alterations in them, as entirely to change their nature.

The order we shall follow in these analyses or decompositions, will be first to examine the substances extracted from vegetables by means which do not occasion any alteration in them.

O N

ON THE JUICES OF PLANTS.

In order to extract the juices of plants, they are pounded, while recent, in a marble mortar with a wooden pestle, and then put to the press. By this method a liquor is extracted which contains the principles of the vegetable, without having undergone any change.

CLARIFICATION OF JUICES.

These juices, immediately after their separation, are turbid, on account of a part of the bruised plant which they contain, and of the resinous matter which is in a state of imperfect solution. In order to clear them, the white of one or more eggs is beat up with them, and they are just brought to boil over the fire. During this process, the white of egg involves and brings with it to the top in form of a scum all the matter that was not perfectly dissolved in the juice.

In this manner the greater part of juices are clarified, which are then called *depurated juices*.

ESSENTIAL

ESSENTIAL SALTS EXTRACTED FROM THE
JUICES OF VEGETABLES.

On evaporating great part of the super-abundant moisture of these juices, they yield, after a certain time, crystals of salts which differ in their nature according to the different species of the vegetables. The greater number of these juices contain all the mineral salts with a fixed alkaline basis; as Glauber's salt, vitriolated tartar, and nitre; but these are not the true essential salts of vegetables.

Those which more properly bear this name are of a different nature. They are such as preserve some of the properties of the vegetable, and in the composition of which there enters a certain quantity of oil; whereas no oily matter enters into the composition of the mineral salts.

EXPRESSED OILS.

The seeds termed oily or *emulsive* yield by contusion and expression an unctuous inflammable juice, called *fatty oil*. All these oils are mild and inodorous, those excepted which are extracted from the seeds of umbelliferous plants,
which

which yields oils of another nature, to be spoken of under the article of essential oils.

Among the mild oils extracted in this manner, some are fluid, as those of sweet almonds, of nuts, &c. others very thick, and even solid, as the oil or butter of cacao, oil of nutmegs, &c.

COMBINATION OF FATTY OILS WITH VITRIOLIC ACID.

The vitriolic acid unites with fatty oils with heat and effervescence, and a strong odour of sulphureous acid. The mixture becomes black, and of a resinous consistence, similar to turpentine.

ANALYSIS OF ARTIFICIAL RESINOUS MATTER.

This artificial resin, submitted to distillation, yields a sulphureous acid, a little sulphur which sublimes at the close of the distillation, and oil, according to the proportions that have been employed.

INFLAMMATION OF FATTY OILS BY THE NITROUS ACID.

The smoking nitrous acid unites to fatty oils with prodigious activity. On mixing them, so
considerable

considerable a heat is produced, that many of them inflame. After the inflammation the coaly matter of the oil remains.

All the fatty oils do not inflame with the nitrous acid singly. The concurrence of the vitriolic acid is necessary to several. The oils of this kind are oil of olives, oil of ben-nuts, oil of pinks, &c. The chemists who appear to have laboured most on this subject, have given nothing sufficiently accurate, either on the theory of the inflammation of these oils by nitrous acid alone, or on the effect of the vitriolic acid in those cases where its concurrence is necessary for the inflammation.

It has been asserted that the effect of the vitriolic acid is to dephlegmate the nitrous acid, and give it more strength; but in order to reason well upon an operation, we must begin with studying the nature of the substances that concur in it.

The fatty oils all resemble each other in their general properties, as unctuousity, inflammability, &c. but they differ in some particular properties which, however, are common to a number
of

of individual kinds. It is to these different properties of fatty oils that we ought to attribute the different facility with which they inflame, either with the nitrous acid singly, or with this acid joined with the vitriolic.

After a great variety of experiments made upon oils, I have found that there are several which possess the property of drying in the air, or of being converted in time to a thick, truly resinous matter. Those of this class are known to the painters by the name of *drying oils*. All these readily inflame with the nitrous acid singly; and those of this kind which dry the soonest, inflame the most easily. Linseed oil may be placed at the head; and of all the fatty oils it is that which is most frequently and successfully used for the experiment. Essential oils, which, it is well known, sooner evaporate and thicken in the air, are for this reason more readily inflamed by the nitrous acid singly, than any of the fatty oils.

I think myself sufficiently authorised to assert, that the effect which the vitriolic acid produces on those fatty oils which cannot be inflamed without its assistance, is to change their
nature

nature, and make them resemble resins. It separates their mucilaginous principle, and seizes the water which is a principle of these oils; in fine, it reduces them to the state of the drying oils which inflame with the nitrous acid singly.

I have mixed olive oil with the vitriolic acid, and when the effervescence was over, have washed in water the resin-like matter, in order as much as possible to take out the acid. This matter, mixed afterwards with smoking spirit of nitre, inflamed as easily as pure linseed oil. Thus, in this experiment, it is certain that the nitrous acid is not dephlegmated by the vitriolic. When a mixture of these two acids is poured upon oil olive to inflame it in the common method, the same thing takes place; that is, the oil is converted into a resinous mass: but this is done instantaneously, and the inflammation usually follows very speedily.

With respect to the theory that has been given of the inflammation of oils by the nitrous acid, it seems to me defective. It is pretended,

1. that the fungus formed during the tumefaction of the oil with the mineral acids is charcoal;
2. that

2. that this coal forms an ash which produces nitre with the nitrous acid.

But it is very certain that the fungus in question, whether produced by the vitriolic acid, the nitrous acid, or both in conjunction, has nothing of the nature of a coal. When submitted to distillation it yields all the principles that oil affords.

As to the supposed production of nitre from the combination of the nitrous acid with the fixed alkali of this pretended coal, this is also an error. In order to effect this combination, a complete combustion of part of the oil would be previously necessary; which does not happen: besides, it is known that oils yield little or no alkali by combustion.

I imagine the inflammation of fatty oils with the nitrous acid is owing to a portion of nitrous sulphur, which is formed by the combination of the nitrous acid with phlogiston. This nitrous sulphur is very inflammable; and the heat excited by the mixture is more than sufficient to inflame it.

WHITE SOAP.

Fixed alkali of soda, rendered more caustic by quicklime, and then put to olive oil, forms a mixture which in the space of some days acquires a good deal of consistence, and is then called *soap*. In order to prepare it, a pound of soap lye is mixed with two pounds of olive oil, and the mixture triturated with a wooden pestle till it has acquired the consistence of a very thick soup. It is then poured into moulds of the form required. In the space of some days it acquires a solid consistence; it is then taken out of the moulds, and exposed to a dry air, which completely hardens it.

DECOMPOSITION OF SOAP BY ACIDS.

If an acid be put into soap-water, it decomposes the soap. The acid unites to the alkali, and separates the oil from it, which swims at top. Well waters loaded with selenites produce the same effect by means of the vitriolic acid they contain. On this account they will not lather with soap.

BALSAM

BALSAM OF SULPHUR, MADE WITH FATTY OILS.

Fatty oils dissolve sulphur with the assistance of heat. This compound bears the name of *Ruland's balsam of sulphur*, when oil of nuts has been employed. Oils when hot hold more sulphur in solution than when cold; hence these balsams in cooling deposite a part of their sulphur.

EMULSIONS.

The seeds which we have called oily or emulsive, ground in a marble mortar with water, form a liquor as white as milk. This has the name of an *emulsion*.

In this mixture, the oil is united to the water, by favour of the mucilaginous matter contained in the oily seeds. It is this oil, prodigiously divided, which produces the milky whiteness of emulsions.

ON MUCILAGES.

The greater part of the oily seeds contain a good deal of mucilage which dissolves in water. Linseed is of this number: boiled in water it
gives

VEGETABLE SUBSTANCES. 283

gives out a very soft mucilage, which has only a slight maukish taste, and resembles glue.

PLASTERS.

Fatty oils by the assistance of heat combine with certain metallic calxes. When combined with calxes of lead, a species of *metallic soaps* are formed, which bear the name of *plasters*.

SPIRITUS RECTOR OF PLANTS.

When an aromatic plant is distilled along with water in a water-bath, there rises, with a degree of heat less than that of boiling water, a very small quantity of an extremely odorous liquor named *spiritus rector*. This liquor contains almost all the odour of the vegetable; is not inflammable; and loses its smell in a short time in the open air, without any loss of weight.

ESSENTIAL OILS.

If an aromatic plant be distilled along with water by a naked fire, there rises, at the boiling heat, *spiritus rector*, and water charged with an oil which either sinks to the bottom, or swims on the surface. This oil is called an *essential oil*.

The essential oils of foreign aromatics are almost all heavier than water; but those extracted

N

from

284 VEGETABLE SUBSTANCES.

from all the vegetables of this country, are lighter than water, and swim on its surface.

EXTRACTS OF VEGETABLES.

The decoction of the plant which remains in the alembic after the distillation of its essential oil, is loaded with the saline extractive parts of the plant. On evaporating this liquor sufficiently, there remains a honey-like matter, which is called an *extract*.

EXHAUSTED PLANTS.

The plant remaining in the alembic, on being repeatedly boiled with fresh water, gives out all the soluble matter it contains. There is left at last only the skeleton or ligneous part of the vegetable.

RECTIFICATION OF ESSENTIAL OILS.

Essential oils, on long keeping, lose a great part of their odour, and are considerably thickened. They sometimes even entirely lose their odour.

When their odour is not quite gone, they are rectified in a retort, in order to separate the
resinous

refinous matter that thickens them, which is formed by the dissipation of the more fluid part of the oils.

When their odour is entirely lost, they are put into an alembic with fresh plants of the same kind, in order perfectly to renew them. This is the best method of rectifying them in such a case.

INFLAMMATION OF ESSENTIAL OILS.

The nitrous acid mixed with essential oils, inflames them with much greater facility than it does the fatty oils.

STARKEY'S SOAP.

Essential oils do not easily combine with fixed alkali. A compound of this kind, made with oil of turpentine and fixed alkali, bears the name of *Starkey's soap*.

Starkey's soap is a composition very difficult to be made, and requiring a considerable time. Few persons well understand what it really is.

My experiments have shewn me that this soap is composed of the refinous part of the oil of
N 2 turpentine

turpentine and fixed alkali. The more fluid and rectified the oil of turpentine is, the less of this soap is obtained; and on adding turpentine to the mixture, the preparation is considerably accelerated. By repeated trials I have assured myself, that all the fluid and spirituous part of the essential oil is dissipated when Starkey's soap is made. Thus, it evidently must be very difficult to determine the proportion of the oil of turpentine to the alkali, since that depends upon the state of the oil. When common essence of turpentine is employed, eight parts are requisite to one of alkali.

To be certain of my theory, I have attempted to make this soap with oil of turpentine rectified in a water-bath with lime flaked in the air. This oil was of extreme tenuity; and forty, or even fifty parts of it to one of alkali were necessary to form a very little of Starkey's soap. On evaporation, this oil left scarcely any resinous matter.

The shortest method of making Starkey's soap was, I found, to grind the alkaline salt with the oil of turpentine upon a porphyry. The oil thus presenting a larger surface, sooner evaporates,

rates, and the soap is more speedily made. This resolves another of the six problems proposed in the *Journal de Medecine*.

NEUTRAL SALT FORMED BY THE ACID OF THE OIL OF TURPENTINE, AND FIXED ALKALI.

Starkey's soap is commonly filled with little crystals of a salt formed by the combination of the acid of the oil of turpentine with the fixed alkali.

This salt is also obtained by digesting oil of turpentine with alkaline salt. By means of filtration the Starkey's soap that forms is separated from the aqueous saline liquor, which, on evaporation, yields crystals, generally in little needles, but sometimes in very large ones, figured in parallelepipeds, especially when the liquor is suffered to evaporate in the open air.

BALSAM OF SULPHUR, MADE WITH ESSENTIAL OILS.

Essential oils dissolve sulphur as well as fatty oils. These compounds bear the name of balsams of sulphur. That in which oil of tur-

pentine is employed is called *terebinthinated balsam of sulphur*; that with oil of aniseeds, *aniseated balsam*, &c. Like the fatty oils, the essential dissolve more sulphur by the aid of heat than they can retain when cold. They, therefore, in cooling deposite the super-abundant sulphur in a crystalline form.

ANALYSIS OF WOOD.

Guaiacum wood is generally taken as an example of this analysis. This wood is hard, compact, resinous, and so heavy as not to swim on water. It yields a good deal of oil by distillation. The substances procured by an analysis of guaiacum are,

1. Phlegm, which rises with a heat a little superior to that of boiling water.
2. An acid spirit, which comes over with a higher degree of heat.
3. A light, somewhat coloured oil, which swims upon the spirit.
4. A black, heavy, thick oil, which sinks to the bottom of the spirit.
5. There remains in the retort a true charcoal.
6. During

6. During the analysis a considerable quantity of air is detached, equal in volume to three hundred times the bulk of the guaiacum.

7. Guaiacum yields also a little volatile alkali, but combined with the acid spirit, and consequently in the state of a neutral, which may be termed a *vegetable ammoniacal salt*. The volatile alkali is produced by the volatilization of part of the fixed alkali, effected by the oily matters of the wood.

FIXED ALKALINE SALT OF VEGETABLES.

The fixed alkali used in the above recited experiments is extracted from the ashes of vegetables.

In order to obtain it, any plant judged fit for the purpose is burned in the open air; the ashes are lixiviated with a sufficient quantity of water; and the lye is evaporated to a certain point in order to separate by crystallization the neutral salts mixed with the alkali. For in the ashes of the greatest part of vegetables, some of the mineral salts, as Glauber's salt, vitriolated tartar, and sea-salt, are contained; but never nitre, on account of its combustibility with phlogistic

matters. When these neutral salts have been separated by crystallization, nothing remains but the alkali.

Alkaline salt, perfectly purified, is always the same from whatever plant it be obtained; but as the separation of the neutral salts is very difficult to effect with all the requisite exactness, the alkalies extracted from different vegetables are not used indifferently. That got from tartar is very pure, and does not contain any foreign saline matters; it is therefore generally preferred to other vegetable fixed alkalies.

FIXED SALT EXTRACTED FROM PLANTS BY THE METHOD OF TACHENIUS.

Tachenius, a physician, desirous of obtaining fixed salts from plants for medical purposes, which should be milder than those procured in the common way, thought of a new method. This consisted in reverberating the smoke and flame upon plants during their combustion, in order that the phlogistic matter might be combined with the alkali. The salts obtained by this method are brown, but they have the properties intended to be given them. They are
loaded

loaded with phlogiston, and approach to the nature of the alkaline liquor impregnated with the colouring matter of Prussian blue.

SALT OF SODA.

Varec and soda are plants growing on the sea-coast. These, with several others of the same species, are burned in great cavities made in the earth. The heat excited during this operation occasions a kind of fusion of the ashes which are left behind. They cohere in masses of considerable bulk; and are afterwards broken into lumps, in which state we get the soda.

In order to extract the marine or mineral alkali which it contains, the soda is reduced to powder, and boiled in water. The filtered lye yields a fixed alkali which crystalises, and the properties of which we have already examined.

POTASH.

Potash is an alkaline salt proceeding from the combustion of certain woods, and from the fluid which exudes from green wood when burned to charcoal. Pans are placed round the heaps of wood to receive the moisture which the

heat expels from both ends. This water is evaporated, and the residuum calcined. It yields a very large quantity of alkaline salt, which is mixed with wood ashes, and forms *potash*.

SALT OF POTASH.

The salt of potash is extracted by dissolving it in water, filtering the liquor, and evaporating it to dryness. This is called *purified potash*, or *salt of potash*.

The alkaline of potash is not pure. It is very often mixed with sea-salt, vitriolated tartar, sometimes Glauber's salt, and generally contains a good deal of marine alkali.

ANALYSIS OF BALSAMS, TAKING TURPENTINE FOR AN EXAMPLE.

Turpentine, in a degree of heat inferior to that of boiling water, yields an essential oil, called *essence*, or *oil of turpentine*. It is clear and colourless. Along with this oil, a little colourless acid phlegm comes over.

BOILED

BOILED TURPENTINE.

After this distillation, there remains at the bottom of the vessel the resinous part of the turpentine, which is called *boiled turpentine*.

On urging this residuum with a degree of heat superior to that of boiling water, there comes over a red oil, much less fluid than that obtained at the beginning of the analysis. It is accompanied with an aqueous liquor, more acid than the former. When the distillation is only carried so far as to obtain these products, what remains in the vessel is dry, brittle, and has scarcely any of the turpentine smell. It is called *colophony*.

BALSAM OF TURPENTINE.

Colophony, urged with a still greater fire, yields an oily matter, as thick as turpentine, called *balsam of turpentine*.

COAL OF TURPENTINE.

There remains in the retort a very small quantity of coaly matter.

N 6

PITCH

PITCH AND TAR.

Pitch is a resinous half-burnt substance, formed by the exudations which proceed from both ends of pieces of old fir wood burned in the middle. The more liquid part forms what is called *tar*.

LAMP-BLACK.

The residuums of turpentine, pitch and tar, which can be applied to no other use, are burned, and the smoke is received into apartments constructed for the purpose. It forms a foot in very light flakes, which is called *lamp-black*.

ANALYSIS OF BENZOIN.

FLOWERS OF BENZOIN.

Benzoin is a pure, very fragrant resin. It yields, by sublimation, with a degree of heat a little superior to that of boiling water, a fragrant volatile salt, crystallised in little needles, called *flowers of benzoin*.

OIL, SPIRIT AND COAL OF BENZOIN.

The residuum after the sublimation of flowers of benzoin, submitted to distillation with a
somewhat

somewhat stronger heat, yields a clear, fluid, fragrant oil, with very little colour; but which continually acquires more and more colour and thickness. At the same time a little liquor passes over in white vapours, which is acid, and has the name of *spirit* or *acid of benzoin*. A true charcoal is left in the retort.

ON CAMPHOR.

Camphor is a concrete essential oil, always solid, of a strong and penetrating odour. It is of a particular nature, and is not susceptible of decomposition by rectification, like oils. Camphor rises entire in close vessels, without suffering any decomposition. It is very inflammable, like the essential oils.

OIL OF CAMPHOR.

The most concentrated acids have no sensible action upon camphor. They unite with it, and cause it to take a liquid form. Camphor liquefied by the nitrous acid bears the name of *oil of camphor*.

If oil of camphor be poured into water, the nitrous acid which held the camphor in a liquid form

form unites with the water, and the camphor is collected in a white mass which swims on the surface. It is found not to have undergone any alteration.

ON BITUMENS.

Bitumens are oily concretions, which belong originally to the vegetable kingdom, and are found in the bowels of the earth. They are under two different states: some are liquid, as *naphtha*, *petroleum*, &c. others solid, as *Jew's pitch*, *amber*, *pit coal*, &c.

ANALYSIS OF PETROLEUM.

Petroleum, called also *oleum petræ*, in a degree of heat a little superior to that of boiling water yields a very thin oil, colourless and very inflammable. This has the name of *artificial naphtha*, or *rectified oil of petroleum*.

By a somewhat stronger fire a red oil is obtained, which becomes more and more thick. Along with these oils an acid liquor comes over in white vapours, which is called *acid of petroleum*. There remains in the vessel a true coal.

ANALYSIS

ANALYSIS OF AMBER.

Amber furnishes on an analysis the following matters ; 1. phlegm ; 2. spirit ; 3. volatile salt ; 4. a white oil ; 5. a red oil ; 6. a thick oil. The residuum is a true coal.

DETONATION OF NITRE BY AMBER.

If a mixture of nitre and amber be heated in a crucible, a detonation takes place ; the oil of the amber burns and is dissipated ; the acid of the amber unites with the alkali of the nitre, and forms a neutral salt which crystalises.

AMBER VARNISH.

Clean amber, after being torrefied by a moderate heat in order to free it from the first principles which rise at the beginning of distillation, is in a state fit for solution in fatty oils. This is the foundation of the beautiful varnish for coaches.

ANALYSIS OF WAX.

Wax is a substance of a middle nature between oils and resins. On an analysis it yields
a small

a small quantity of fluid oil, and then an oil which appears as fluid as the first, but which on cooling acquires almost as much consistence as wax itself. With these oils a small quantity of acid liquor comes over, which proceeds from the decomposition of the wax.

By a great number of successive distillations, the oil of wax is rendered fluid like the essential oils; and it does not grow thick through age, as they do.

BLEACHING OF WAX.

Wax, in its usual state, is yellow. This colour is discharged, and it is rendered white, by the combined action of air and water. This action occasions the separation of a part of its acid, which operates like the sulphureous acid, and destroys the colour of the wax.

In order to facilitate the destruction of the colour, the wax is melted, and poured into water round a cylinder of wood, which reduces it into very thin ribbons. In this state it is exposed to the air and dew; and when whitened on its surface, it is melted again to give it a
fresh

fresh surface, and again exposed to the air. This process is repeated till the wax becomes sufficiently white throughout.

ON GUMS.

Gums are only thickened mucilages, which are precisely of the same nature as the mucilages of which we have spoken. In their analysis they furnish the same substances, and in the same proportions.

Gums are distinguished by the following properties.

1. They are of a compact texture.
2. They are insipid and inodorous.
3. They dissolve in water, without injuring its transparency, and are then converted into mucilages.
4. They are insoluble in oil, and spirit of wine.
5. When well dried they do not liquefy on the fire, but puff up and burn.

6. Gums

6. Gums, in burning, do not flame till they are almost reduced to a coal.

All these properties shew that very little oil enters into the composition of mucilages and gums.

ANALYSIS OF GUMS.

Gum Arabic is usually taken as an example of this analysis. It yields a good deal of slightly acid phlegm, and some drops of oil.

There remains at the bottom of the vessel a coaly matter which is rarefied, and occupies a good deal of room.

ON GUMMY RESINS.

Gummy resins are mixtures of gum and resin presented to us by nature in this state of combination. They, consequently, participate of the properties of both gums and resins.

They are less friable than pure resins, and less hard than gums. They are sapid and odorous.

They whiten water in which they are diffused, and form emulsions; which is owing to the
resinous

resinous part which, being in a very divided state, remains suspended in the water.

Gummy resins do not totally dissolve in spirit of wine. The purely resinous part alone dissolves in this liquor; the purely gummy part precipitates.

They rarefy less in the fire than gums, and burn more readily.

ANALYSIS OF GUMMY RESINS.

Gummy resins in their analysis yield less oil than resins, but a good deal more than simple gums; and the same is true with respect to the quantity of acid they give out.

ON SACCHARINE JUICES.

The substances called *saccharine juices*, are such as have a sweet agreeable taste, approaching to that of sugar, and which are capable of producing a spirituous liquor by fermentation. Substances of this kind are sugar; manna; honey; the juices of several vegetables, as pears, apples, grapes; the small portion of sap in a
green

302 VEGETABLE SUBSTANCES.

green ear of corn ; the honey-like juice in the flower cup of pinks, jessamine, &c.

All these matters are of the same nature, and give out the same principles on an analysis. We shall take honey for an example.

ANALYSIS OF HONEY.

DEW OF HONEY.

Honey, with the heat of boiling water, yields a liquor which has all the odour of honey, and is called *dew of honey*. It is without taste.

ACID OF HONEY.

With a stronger heat, honey gives out a very large quantity of a pretty strong acid, which has an empyreumatic smell, on account of a small portion of burned oil which comes over with it. Honey, like the rest of the saccharine juices, yields little oil during its analysis. The acid of honey effervesces and combines to the point of saturation with alkali, forming a neutral salt which crystalises.

COAL OF HONEY.

After the analysis of honey, there remains at the bottom of the vessel a light spongy coal.

ON FERMENTATION.

Chemists distinguish fermentation into three periods; to wit, that of the *spirituous*, of the *acid* or *acetous*, and of the *putrid* or *alkalescent fermentation*. We shall give an idea of these three states of fermentation, in proportion as the train of subjects will lead us to them; and we shall now begin with the *spirituous*.

ON THE SPIRITUOUS FERMENTATION.

The spirituous fermentation is an intestine motion, accompanied with heat, which disunites the principles of a fermentible juice; combines them in a different manner, in changing their nature; and separates them into two parts, one named *wine*, the other *dregs* or *lees*.

All saccharine and farinaceous substances are susceptible of the spirituous fermentation, and capable of forming wine. The business of
fermen-

304 VEGETABLE SUBSTANCES.

fermentation is too extensive to allow us in this place to enter into a larger detail on the subject: we shall proceed to examine the wine which is its product.

DISTILLATION ON WINE---BRANDY.

Wine distilled by a less heat than that of boiling water, yields a spirituous and very inflammable liquor, which is the substance called *brandy*.

EXTRACT OF WINE.

What remains at the bottom of the vessel is an acid liquor, loaded with extractive principles; which, when evaporate to the consistence of a conserve, forms what is called *extract of wine*. We shall examine it hereafter.

SPIRIT OF WINE.

On distilling brandy with a water-bath it is freed from a great part of its phlegm and gross oil, and becomes *spirit of wine*. On re-distilling this spirit several times, the *rectified spirit of wine* is procured.

WATER

WATER OF RABEL.

Rectified spirit of wine digested with vitriolic acid forms a combination called *water of Rabel*. The proportions are one part of concentrated acid to three of spirit of wine.

VITRIOLIC ÆTHER.

A mixture of equal parts of rectified spirit of wine and concentrated vitriolic acid, submitted to distillation, yields a spirituous very inflammable liquor, named *æther*. The detail of this process may be seen in my dissertation on *æther*.

VOLATILE SULPHUREOUS VITRIOLIC ACID OBTAINED BY THE DISTILLATION OF VITRIOLIC ÆTHER.

When the *æther* ceases to come over, there rises an aqueous acid liquor, of an active penetrating and suffocating odour. This is sulphureous acid, which is formed by a portion of the vitriolic acid volatilised by the oily and phlogistic substance of the spirit of wine.

OIL OF WINE.

With this sulphureous acid there passes over a certain quantity of oil which swims on the surface of the acid liquor. This oil is that which was one of the constituent principles of the spirit of wine. Chemists have named it *sweet oil of vitriol*, but improperly. It is the essential oil of the spirit of wine.

RESIDUUM OF ÆTHER. .

After the distillation of these products, there remains in the retort a black vitriolic acid, with a strong smell of burning sulphur. This, by rectification, may be purified from all the foreign matters it contains, and made to re-appear with all the properties it had before being used in this process.

RECTIFICATION OF ÆTHER.

The æther, obtained by the process above described, is mixed with a certain portion of spirit of wine, which rose in the beginning of the operation, and had not time to be converted into æther. This is separated by a second distillation, which is termed *rectification*.

THE

The æther, as more volatile, rises first, and the spirit of wine remains at the bottom of the vessel.

EXAMINATION OF THE PROPERTIES OF RECTIFIED VITRIOLIC ÆTHER.

Æther has a strong, penetrating, tolerably agreeable smell. It heats a little on mixture with water, but much less than spirit of wine.

It is vastly more inflammable than spirit of wine; it gives a lively brilliant flame, and yields a little soot, which spirit of wine does not.

It dissolves all essential and fatty oils in all proportions; which is not the case with spirit of wine.

It instantly seizes upon gold dissolved in aqua régia, as essential oils do; a property not possessed by spirit of wine.

All these properties of æther prove that it approaches to the nature of essential oils, by so much as it recedes from that of spirit of wine.

O

It

308 VEGETABLE SUBSTANCES.

It holds, in some measure, the middle rank between these substances.

One of the curious properties of æther, which proceeds from its great evaporability, is that of producing a cold sufficient to sink the liquor of Reaumur's thermometer 25 degrees* below its usual temperature, and 41 or 42 degrees when the experiment is tried *in vacuo*.

DULCIFIED SPIRIT OF NITRE.

A mixture of two parts of spirit of wine and one of common spirit of nitre, digested in the cold during some days, forms a liquor in which the properties of the nitrous acid are very much deadened. This is the *dulcified spirit of nitre*.

NITROUS ÆTHER.

A mixture of six ounces of spirit of wine, and four ounces of smoking spirit of nitre, digested in a glass vessel surrounded with ice, forms, at the end of some days, a liquor which separates from the mixture, and swims above

* A degree of Reaumur's thermometer is somewhat more than two of Fahrenheit's. J. A.

the acid part. This is called *nitrous æther*. My dissertation on æther may be consulted for the precautions necessary in this process.

The action of nitrous acid on spirit of wine is so strong, that it is necessary to repress it by cooling the mixture with ice, without which considerable explosions would happen. For this reason the operation cannot be performed by distillation, as is done with respect to vitriolic æther.

RESIDUUM OF NITROUS ÆTHER.

The liquor above which the nitrous æther swims, is very acid. It contains a small portion of æther in solution.

EXAMINATION OF THE PROPERTIES OF NITROUS ÆTHER.

This æther is of a light lemon colour, which is owing to a part of the oil of the spirit of wine, that has been a little burned by the nitrous acid.

It has an acid taste, owing to a portion of nitrous acid which it contains.

310 VEGETABLE SUBSTANCES.

It mixes with water in certain proportions, like vitriolic æther: some drops of oil swim on the surface, which is called *sweet oil of nitre*.

On evaporating, it produces almost as much cold as vitriolic æther.

It burns with a soot, and leaves behind it a coaly matter. Its flame is yellowish.

DULCIFIED SPIRIT OF SALT.

Spirit of wine and marine acid digested together form *dulcified spirit of salt*.

The marine acid does not combine with spirit of wine so readily as the other mineral acids; which proceeds from the little disposition we have observed it to have for uniting with the phlogiston. Nevertheless, when this acid has been freed from certain principles, by the assistance of some metallic substances, it combines with spirit of wine nearly as well as the vitriolic acid; and, in this state, presents similar phenomena.

MARINE ÆTHER.

Equal parts of spirit of wine and the smoking liquor of Libavius are mixed together, and the
mixture

mixture distilled. An ætherial liquor is procured, similar to vitriolic æther, and with all its properties. This process was discovered some years ago by the Marquis de Courtanveaux.

TINCTURE OF SALT OF TARTAR.

Spirit of wine, digested on very dry salt of tartar, acquires in a few days an amber tinge. This colour is produced by the action of the alkali upon the oily principles of the spirit of wine. The alkali in some measure burns the oil of the spirit of wine, in part combines with it, and forms with it a sort of reddish soap, which dissolves in the spirit of wine, and tinges it.

LILIUM OF PARACELSUS, OR TINCTURE OF METALS.

A mixture of copper and antimony, another of regulus of antimony and tin, and regulus of antimony, nitre and tartar, are melted together in a crucible, and then poured into a mortar. They are introduced as hot as possible into a matrafs, and spirit of wine is poured upon them. The mixture is digested till the spirit has acqui-

312 VEGETABLE SUBSTANCES.

red a red colour. This is the *lilium* or *tincture of metals*

Part of the metallic substances calcines during their fusion, by means of the nitre: the tartar and nitre alkalise together: the small portion of metallic calx augments the causticity of the alkali, which thereby becomes more able to act upon the oily principles of the spirit of wine. It is for this reason that this tincture is a little more coloured than the tincture of salt of tartar.

ON VEGETABLE SPIRITUOUS TINCTURE.

Spirit of wine dissolves the resin contained in vegetables, and forms so many mixtures which bear the name of tinctures. We shall take for example tincture of jalap, because this root furnishes a good deal of resin.

TINCTURE OF JALAP.

Jalap in gross powder is put into a matraass, and spirit of wine poured upon it. The mixture is digested till the spirit has acquired a reddish tinge. The liquor is then filtered, and is the *tincture of jalap*.

RESIN

RESIN OF JALAP.

On pouring tincture of jalap into water, a white milky mixture is instantly formed. The spirit of wine unites with the water and quits the resin, which, being in an extremely divided state, makes the water white; but by degrees the resin precipitates, and the water clears. The resin when collected has a liquid consistence like turpentine. It is dried by a gentle heat.

GUMMY EXTRACT OF JALAP.

The jalap, from which all the resin that spirit of wine would dissolve has been separated, yields by decoction in water an extractive matter which has a good deal of the nature of gums.

EXHAUSTED JALAP.

There remains at last, after all these operations, the exhausted jalap, which will give out nothing more either to water or spirit of wine.

SOAP DISSOLVED IN SPIRIT OF WINE.

Spirit of wine, as we have already observed, does not well dissolve fatty oils, and has scarcely

any action upon alkalies ; but when these substances are combined in form of a soap, spirit of wine dissolves them with sufficient facility, and in large quantity.

SPIRIT VARNISH.

Spirit of wine, loaded with resinous matters, forms *varnish*. When these solutions are applied on a body, the spirit evaporates, and leaves the resinous substances under the form of a shining coating, like ice. But these varnishes dry considerably in the air, and split or crack ; an inconvenience to which oil varnishes, that is, solutions of resins in fatty oils, are not subject.

ON SPIRITUOUS OR AROMATIC WATERS.

We have remarked that spirit of wine perfectly dissolves essential oils. If aromatic plants, therefore, are submitted to distillation in a water-bath with spirit of wine, this liquor comes over, and carries with it the essential oils of the vegetables, and holds them in solution. This is the method in which all simple spirituous aromatic liquors are made ; as spirit of lavender,
of

of thyme, of citron, &c. By the same method, also, compound spirituous aromatic liquors, in which several vegetable substances enter, are made.

MIXTURE OF SPIRITUOUS WATERS WITH WATER.

When these spirituous aromatic liquors are mixed with water, the spirit of wine unites with the water, and the oil separates; which, being in an extremely divided state, renders the waters milky.

GUM DISSOLVED IN WATER, AND PRECIPITATED BY SPIRIT OF WINE.

When spirit of wine is added to a solution of gum arabic in water, it seizes on the water, and throws down the gum under the form of a white powder, because, as we have seen, gum will not dissolve in spirit of wine.

EFFECTS OF SPIRIT OF WINE ON SALTS.

Spirit of wine dissolves neutral salts with difficulty; on the contrary, it facilitates their crystallization. If, to a solution of nitre, spi-

316 VEGETABLE SUBSTANCES.

rit of wine be added, it seizes the water, and crystallises the salt in an instant.

SEDATIVE SALT DISSOLVED IN SPIRIT OF WINE.

Sedative salt dissolves in small quantity in spirit of wine, but only through favour of the water the spirit contains.

If this solution be set on fire, the flame appears of a greenish yellow, which colour is owing to the combination of the sedative salt with the phlogiston of the spirit of wine.

ON TARTAR.

Tartar is the essential salt of wine. It is found adhering to the sides of casks. There is a red and a white sort.

CREAM OF TARTAR.

Tartar is purified at Montpellier. For this purpose, it is boiled in water with argillaceous earths, on which tartar has no effect. These earths are employed to free the tartar from its superabundant oil. The liquor filtered and set
to

to crystalise, yields crystals which are called *crystals of tartar*, *purified tartar*, or *cream of tartar*.

ANALYSIS OF TARTAR.

Tartar, or crystals of tartar, submitted to distillation, yield the following substances:

1. an acid spirit; 2. an empyreumatic oil;
3. a coaly alkaline salt.

Tartar is almost the only substance which furnishes a pretty large quantity of fixed alkali by combustion in close vessels. Stahl attributes this effect to the great quantity of air which is detached from tartar during its analysis. According to the experiments of Hales in his *Vegetable Statics*, this amounts to a third of the weight of the tartar.

CRUDE OR WHITE FLUX.

One part of nitre and two of tartar form what is called the *crude or white flux*. This mixture is used for the fusion and reduction of ores and metallic calxes.

BLACK FLUX.

The crude flux above-mentioned detonates briskly by means of kindled charcoal, and the nitre and tartar mutually alkalise each other. If this inflammation be effected in a mortar slightly covered, part of the smoke that rises from the tartar combines with the alkali which is the product of the inflammation, and renders it black and phlogistic. This forms a very good reductive of metals.

NITRE FIXED BY TARTAR.

A mixture of equal parts of nitre and tartar detonates more briskly than the preceding mixture. As a greater quantity of nitre enters into this latter, there is enough entirely to destroy the coaly matter which the tartar might form. This *nitre fixed by tartar* is a white, pretty pure alkaline salt.

SOLUBLE TARTAR, OR VEGETABLE SALT.

Cream of tartar unites with fixed alkali with effervescence, to the point of saturation. From this combination there results a neutral salt which
crystalises

crystallises difficultly, when the liquor is made perfectly neutral; but easily, when there is a superabundance of alkali.

SOLUBLE TARTAR MADE WITH ABSORBENT
EARTHS.

Cream of tartar unites with absorbent earths with effervescence. This combination furnishes crystals similar to the preceding, but which differ in their basis.

SALT OF SEIGNETTE.

Cream of tartar combines with effervescence to the point of saturation with the marine alkali. From this combination results a salt which forms larger crystals than the preceding. This is the *salt polychrest of Rochelle*, or *salt of Seignette*.

PRUSSIAN BLUE, MADE WITH THE MOTHER-
WATER OF SALT OF SEIGNETTE.

If vitriolic acid be poured into the mother-water of salt of Seignette, a Prussian blue is instantly produced. The reason of this is, that the marine alkali always holds a little iron in solution, through favour of its phlogiston.

TINCTURE

TINCTURE OF MARS.

Tartar unites with iron with effervescence. This combination forms a deliquescent neutral salt, which does not crystallise. It is kept in a liquid form, with a little spirit of wine added, to prevent it from growing mouldy. This is the *tincture of Mars*.

BALLS OF MARS.

Two parts of tartar and one of iron filings, moistened with a little water, combine, and form a resin-like extractive mass, with which balls are made, called *balls of Mars*, or *balls of Nancy*.

EMETIC TARTAR.

Cream of tartar combines with glass of antimony to the point of saturation. This forms *tartar emetic*, *stibiatis tartar*, or *sal Mochlitis*.

In this process, the tartar only combines with the reguline part of the antimony which is deprived of a sufficient quantity of phlogiston. On this account, it cannot form a combination with
regulus

regulus of antimony itself, because it possesses all its phlogiston.

ON THE ACID FERMENTATION.

The acid fermentation is the second degree of the spirituous fermentation: it tends to combine in a different manner the principles which are formed and separated in the first fermentation.

We shall define the acid fermentation, an intestine motion, which continues, or which is artificially renewed, among the particles of a liquor that has undergone the vinous fermentation, and the effect of which is to convert the wine into an acid liquor named *vinegar*, by combining the spirituous part of the wine with the other principles, more intimately than before.

Spirit of wine is a principle essential to vinegar: it remains in it combined with the other principles so intimately that it cannot be separated by distillation. Nevertheless, it manifests itself in the operations that we are presently to mention.

All

322 VEGETABLE SUBSTANCES.

All liquors that have undergone the spirituous fermentation, are capable of being converted into vinegar by passing through the second degree of fermentation. Such are beer, cyder, wine, made wines, &c.

DISTILLED VINEGAR.

Vinegar submitted to distillation, yields a clear acid liquor, which has all the properties of the vinegar before distillation, except that it is without colour, which it loses from being deprived of its extractive parts.

When vinegar is newly made, the first portion of liquor that distills is inflammable, containing a good deal of spirit of wine; but when it is old, this portion of spirit is so combined with the other principles of the vinegar, that it is no longer perceptible in distillation. All the liquors which have undergone the spirituous and acid fermentation are alone capable of giving out an acid liquor by distillation with the heat of boiling water. On the contrary, all the vegetable acid juices, such as that of lemons, or barberries, verjuice, &c. only yield an absolutely infpid water: their acid is not attenuated by a
spirituous

spirituous principle, and is incapable of rising in distillation with the heat of boiling water.

EXTRACT OF VINEGAR.

After the distillation of vinegar, there remains at the bottom of the vessel a substance of the consistence of honey. This is called *extract of vinegar*.

VINEGAR CONCENTRATED BY FROST.

When vinegar is exposed to frost, its aqueous part freezes. If the ice thus formed be separated, what remains of the vinegar is much stronger, because the truly acid part does not freeze, at least without a very considerable degree of cold, seldom met with in our climate.

TERRA FOLIATA TARTARI.

Distilled vinegar unites with fixed alkali with effervescence to the point of saturation, and forms a neutral salt, which is very sapid, and deliquescent. During the combination a light acid is disengaged, which is as brisk and penetrating as the sulphureous vitriolic acid.

COM-

COMBINATION OF VINEGAR WITH CRY-
STALS OF SODA.

Distilled vinegar and crystals of soda form a combination similar to the preceding, but which has less sharpness in its taste, and crystalises in needles like Glauber's salt. It has the name of *crystalised terra foliata*. This salt does not attract the moisture of the air like the former, neither does it fall into efflorescence, at least not without much difficulty.

COMBINATION OF VINEGAR WITH ABSOR-
BENT EARTHS.

Vinegar dissolves absorbent earths with effervescence to the point of saturation, and forms with them salts which crystalise, and do not attract moisture from the air. These salts bear the name of the earth employed ; as *salt of chalk*, when chalk is employed ; *salt of crab's-eyes*, *salt of coral*, &c.

MAGISTERY OF CRAB'S-EYES.

Fixed alkali decomposes all the vegetable salts with an earthy basis above-mentioned,
uniting

uniting with the acid of the vinegar, and precipitating the earth. These precipitates are called *magisteries*: that proceeding from the decomposition of salt of crab's-eyes is the *magistry of crab's-eyes*; and so of the rest. The precipitates are washed in several waters and dried. The filtered liquor on evaporation yields *terra foliata*.

VERDEGRIS OR VERDET.

Vinegar combines also with different metallic substances.

Verdegris is the rust of copper, the formation of which is facilitated by means of wine and grape stalks. Copper plates are alternately stratified with the husks and stalks of grapes moistened with wine: when the copper is sufficiently rusted, the verdegris is collected, and formed into masses, which are usually wrapt in sheep-skin bags.

CRYSTALS OF VERDEGRIS.

Verdegris, as we have just observed, is rusted copper. Part of it is in a saline state, but the greater part is purely a metallic calx.

If

If verdegris be digested with distilled vinegar, the vinegar becomes loaded with it to the point of saturation, This forms a green solution, which, by crystalization, yields very beautiful blue crystals, called *crystals of Venus*; and, by the painters, *distilled verdegris*. These have an acid metallic taste. They do not attract moisture from the air, but rather grow drier in it.

RADICAL VINEGAR.

All the vegetable salts composed of vinegar and absorbent earths, fixed alkalies, or metallic matters, are capable of decomposition by the action of fire. The acid procured from them is very concentrated. It has an extremely penetrating odour of vinegar, and is inflammable. This acid is called *radical vinegar*; and when got from the crystals of Venus, *spirit of Venus*.

There remains in the retort (in the last case) a calx of copper, which may be reduced by melting in a crucible with a little alkali and phlogistic matter.

Most chemists have said that radical vinegar contains an inflammable substance, and is itself
partly

partly inflammable: but the Count de Lauragais has shewn, 1. that radical vinegar is totally inflammable; 2. that in order to inflame it either totally or impartially it must be kept in a boiling heat. It is in this that his discovery principally consists, which has been unjustly contested with him.

The inflammable part of the acid obtained from the crystals of Venus, is the portion of spirit of wine that was combined in the vinegar, and which is disengaged from the other principles by a kind of decomposition which the vinegar undergoes during these operations.

On rectifying these acids, they all yield, at the beginning of the distillation, an ætherial liquor similar to that we are going to mention.

ACETOUS ÆTHER.

A mixture of equal parts of spirit of Venus and spirit of wine, yields, on distillation, an ætherial liquor, very similar to vitriolic æther, which is called *acetous æther*. We are indebted

328 VEGETABLE SUBSTANCES.

ed to the Count de Lauragais for this discovery.

WHITE LEAD.

Lead, exposed to the steams of vinegar, has its surface converted into a kind of white rust. This is collected in the form of flakes of a line or a line and a half in thickness, which are hard and very compact. They have the name of *white lead* or *flake white*.

White lead may be resembled to verdegriis with respect to the state in which it is procured ; part being in a saline state, and a greater part in that of a white calx.

CERUSS.

White lead is trituated with a third or thereabouts of white chalk, and a sufficient quantity of water. The mixture is put into funnels in order to be formed into little conical loaves. These are the *cerufs*.*

* We generally consider *white lead* and *cerufs* as the same, and reckon the mixture of chalk an adulteration. J. A.

VINEGAR

VINEGAR OF SATURN.

Distilled vinegar dissolves white lead readily to the point of saturation. This combination has a sweet saccharine taste. It is called *vinegar of Saturn*.

SALT OF SATURN.

Vinegar of Saturn, set to evaporate, yields a salt crystalised in little needles, which is called *salt*, or *sugar*, of *Saturn*. Its name of *sugar* is given on account of its saccharine taste.

DECOMPOSITION OF GLAUBER'S SALT BY
SALT OF SATURN.

If Glauber's salt and salt of Saturn are ground together on a porphyry, the mixture is reduced to a paste, and two decompositions and two new combinations are formed. The vitriolic acid unites with the lead, forming a vitriol of lead; the vinegar unites with the marine alkali, and forms the crystalised *terra foliata* of which we have spoken above.

SPIRIT OF SATURN.

Salt of Saturn submitted to distillation yields

330 VEGETABLE SUBSTANCES.

an acid similar to that procured from the crystals of Venus, and like it inflammable.

There remains at the bottom of the vessel a calx of lead, which may be reduced by the addition of phlogiston.

SOLUTION OF MERCURY IN DISTILLED VINEGAR.

Distilled vinegar has no action upon mercury while in an aggregate form; but if mercury precipitated from the nitrous acid by fixed alkali be taken, the vinegar dissolves it thus divided, and they form together a neutral salt, which crystallises very readily. These crystals are very brilliant, silvery, and in thin flakes like sedative salt; but they unite in drying, and form thin extremely light little plates. This salt has of late years been employed for the cure of venereal complaints.

ON PUTREFACTION.

Putrefaction may, I conceive, be considered as a spontaneous analysis, without heat; or a subsidence and laceration of the particles of bodies, by the weight of their mass, and by the dilatation

dilatation of the fluids they contain, but aided by the external heat of the atmosphere. This spontaneous analysis disengages the aqueous, oily and saline principles of which the bodies consisted.

The saline substance which purified bodies furnish, is always the volatile alkali, whether they are of the animal or vegetable kingdom: hence has arisen the name of *alkalescent fermentation*.

In order to render plants putrid, any quantity of them is put into a vessel, and crushed, with the addition of a little water if the plants are dry. After a time they heat considerably; but this heat is only occasioned by the two first degrees of fermentation which precede putrefaction: when they are really in a putrid state, they produce neither heat nor tumefaction. They are left till they are thoroughly putrefied, and exhale the smell of fecal matters.

ANALYSIS OF PUTREFIED PLANTS.

Putrefied plants give out, with the heat of boiling water, a fetid liquor, which contains

P a little

a little volatile alkali, and turns syrup of violets green.

With a stronger degree of heat they yield an empyreumatic oil, a concrete volatile alkali, and water loaded with volatile alkali. At the bottom of the vessel there remains a true coal, containing fixed alkali, which may be extracted by lixiviation, without any other combustion.

EXAMINATION OF THE PROPERTIES OF VOLATILE ALKALI.

Volatile alkali is met with both in a dry and in a liquid form.

These alkalies have an urinous, strong, and penetrating odour.

They are very volatile, and are dissipated in the air with extreme facility. As they rise entire in the heat of the boiling water, they are rectified by sublimation.

They turn syrup of violets green.

VITRIOLIC AMMONIACAL SALT.

The volatile alkali unites with the vitriolic acid to the point of saturation, with heat and
effe-

effervescence. This combination furnishes a salt in needled crystals, named *vitriolic ammoniac*, or *secret salt of Glauber*.

NITROUS AMMONIACAL SALT.

The volatile alkali and nitrous acid unite with the same phenomena, and yield a neutral salt which crystalises in needles.

This salt detonates and inflames like common nitre; with this difference, however, that as a good deal of phlogiston enters into its composition, it inflames singly, without requiring the aid of foreign phlogiston. It is sufficient to put it into a crucible previously made red hot.

SAL AMMONIAC.

The marine acid combined with the volatile alkali yields *common sal ammoniac*. It is in crystals resembling the feather of a quill.

DECOMPOSITION OF SAL AMMONIAC BY THE / VITRIOLIC ACID.

The vitriolic acid decomposes sal ammoniac by disengaging the marine acid, and uniting

P 2

with

334 VEGETABLE SUBSTANCES.

with the volatile alkali, with which it forms vitriolic ammoniac.

AQUA REGIA MADE WITH NITROUS ACID AND SAL AMMONIAC.

The nitrous acid unites with sal ammoniac with considerable heat and effervescence, on account of the phlogiston contained in the sal ammoniac: this forms an aqua regia which dissolves gold very well. Some chemists have imprudently advised distilling this mixture to dryness, in order to form a more intimate combination of the nitrous acid with the sal ammoniac; but they seem to be ignorant that the nitrous acid in this mixture combines with the volatile alkali, and that thence results a nitrous ammoniac which detonates in the retort, and produces an explosion, whenever it is sufficiently heated.

DECOMPOSITION OF AMMONIACAL SALTS BY FIXED ALKALI.

Fixed alkali decomposes all ammoniacal salts, by uniting with their acid, and disengaging
their

their volatile alkali, which is obtained in its proper form.

There remains in the retort after the decomposition of vitriolic ammoniac, a vitriolated tartar; after that of nitrous ammoniac, common nitre. In the decomposition of the latter a good deal of caution is requisite, on account of the facility with which it inflames in close vessels.

After the decomposition of common ammoniac, there remains a regenerated sea-salt, or febrifuge salt of Silviuſ, which ſome improperly called *fixed ſalt*, and *fixed ſal ammoniac*.

DECOMPOSITION OF AMMONIACAL SALTS BY ABSORBENT EARTHS.

Absorbent earths decompoſe all the ammoniacal ſalts, uniting with their acid, and diſengaging the volatile alkali, which is generally in a concrete form. The reſiduums are neutral ſalts with an earthy baſis; viz. ſelenites, after the decomposition of vitriolic ammoniac; nitre with an earthy baſis, after that of nitrous ammoniac;

niac; and sea-salt with an earthy basis, after that of common ammoniac.

DECOMPOSITION OF AMMONIACAL SALTS
BY QUICKLIME.

Quicklime, as well as absorbent earths, decomposes ammoniacal salts, but with different phenomena. The volatile alkali obtained by its means is always under a fluid form. The cause of this is, that the lime seizes a certain quantity of the oil which is one of the substances essential to the concrete form of the volatile alkali.

This is what Mr. Duhamel of the Academy of Sciences has demonstrated in a satisfactory manner, as may be seen in the Memoirs of the Academy for the year 1735. This writer shews, that when the lime is impregnated with phlogistic matters, it decomposes sal ammoniac in the same manner as pure absorbent earths, that is, the volatile alkali is obtained under a concrete form.

Some persons, who probably were not acquainted with Mr. Duhamel's Memoirs, have
proposed

proposed a problem* on this subject, in which they assert “that by means of quicklime the volatile alkali of sal ammoniac may be obtained either in a concrete or fluid form according to the will of the artist.” But we may presume that these persons did not know the alterations that pure quicklime occasions in the volatile alkali; otherwise they would not have said that neither preparation nor the addition of foreign matters was necessary to the lime.

I have repeated all those of Mr. Duhamel’s experiments which support his theory, and which relate to the object in question; and I am fully convinced that the author of the problem is evidently mistaken. The following experiment appears decisive to the point.

I powdered three ounces of quicklime, and mixed it with an equal weight of dried oxes blood. I calcined the mixture till it ceased to flame. I powdered it again, and added the same quantity of dried blood. I calcined this matter in a covered crucible, and kept it in a

* *Journal de Medicine* for October 1762, p. 366.

white heat for more than an hour. I then took out the matter, which was very black. The lime had lost all the properties of quicklime, no longer producing heat with water, as it does when pure.

I made use of this lime to decompose sal ammoniac, and obtained only a concrete volatile alkali, with very little liquor. I lixiviated with water the matter remaining in the retort; it yielded marine salt with a fixed alkaline basis, and a very little marine salt with an earthy basis.

The lime in this calcination consequently changed its nature. The added phlogistic matter converted a great portion of the calcareous earth into quicklime; whence it follows,
 1. that in order to obtain concrete volatile alkali from sal ammoniac decomposed by lime, the lime must be overcharged with phlogistic matter :
 2. that fixed alkali is composed, as I have formerly observed, of earth, phlogiston, and water. *

OIL

* According to Dr. Black's theory, confirmed by the most accurate experiments, it appears that the sole cause of the different

OIL OF LIME.

The residuum after the decomposition of sal ammoniac by means of pure quicklime, contains a sea-salt with an earthy basis. This matter is lixiviated in a sufficient quantity of water, the liquor filtered, and evaporated to the consistence of a syrup. It yields on cooling a crystalline mass, in which crystals are distinguished. This salt dissolved in water and filtered, forms a liquor named *oil of lime*.

DECOMPOSITION OF SALTS WITH AN EARTHY BASIS BY THE VOLATILE ALKALI.

The volatile alkali obtained in decomposing sal ammoniac by fixed alkali or absorbent earths, decomposes all the felenites, and nitre and sea-salt with earthy bases.

ent states in which volatile alkali is procured, is the presence or absence of fixed air in the substance effecting the decomposition. Thus, chalk and mild fixed alkali always detach the volatile alkali of sal ammoniac in a concrete form; quicklime and caustic alkali, in a fluid form. J. A.

But the fluid volatile alkali obtained by means of quicklime, scarcely at all decomposes the salts with an earthy basis; it only precipitates a very small quantity of earth.

These phenomena shew that the quicklime has considerably altered the nature of the volatile alkali.

DECOMPOSITION OF SAL AMMONIAC BY CALX OF LEAD. PLUMBUM CORNEUM.

Calx of lead decomposes sal ammoniac like earthy calxes. It detaches the volatile alkali, which has considerable strength, and is always in a liquid form.

The marine acid of the salt unites with the lead, and forms with it the *plumbum corneum*, which is used in the process for making phosphorus.

FULMINATING GOLD.

The volatile alkali precipitates gold from its solvent. The precipitate collected is of a yellow colour. It fulminates and detonates in a very moderate

moderate heat, with very considerable noise and explosion. I imagine this effect to proceed from a portion of the nitrous sulphur, formed by the union of the phlogiston with the nitrous acid which has fallen down along with the gold.*

DECOMPOSITION OF SAL AMMONIAC BY IRON.

Iron decomposes sal ammoniac, and detaches its volatile alkali. If a mixture of iron and well-dried sal ammoniac be sublimed, the sal ammoniac, for want of moisture, rises in substance with a little iron. This sublimate is of a yellow colour, and forms what is called *Ens Martis*, or *martial flowers of sal ammoniac*.

DECOMPOSITION OF SAL AMMONIAC BY COPPER.

Copper decomposes sal ammoniac, and detaches its volatile alkali. This mixture, well-dried and sublimed, forms *Ens Veneris*, or *coppery flowers of sal ammoniac*.

* Bergman has refuted this theory by proving that it may be made by the marine acid alone. M.

AQUA COELESTIS.

Lime water and fal ammoniac, suffered to stand together in a copper bason, acquire a fine blue colour. This is called *aqua cœlestis*.

BLUE COLOUR WHICH DISAPPEARS FOR
WANT OF AIR.

If volatile alkali and copper filings are put into a phial, a fine blue tincture is produced. On stopping the phial closely the colour disappears some time after, but appears again on opening it; and this phenomenon may be renewed a great number of times.

WHITE PRECIPITATE OF MERCURY.

If corrosive sublimate and fal ammoniac are dissolved together in water, on the addition of fixed alkali a mercurial precipitate of a very fine white is directly thrown down.

In this process, the fixed alkali unites with the marine acid of the corrosive sublimate, and with the marine acid of the fal ammoniac; the volatile alkali of the fal ammoniac is disengaged; and the mercury, deprived of acid, is obliged to precipitate.

EAU DE LUCE.

The volatile alkali unites with oily matters, and forms with them kinds of soap. The liquor named *Eau de Luce* is made with rectified oil of amber and fluid volatile alkali obtained by means of quicklime.

Eau de Luce, to be fine, should be of a milky white; and there should be no separation of the saponaceous matter, but it should remain united to the volatile alkali.

ANALYSIS OF SOOT.

Soot on its analysis furnishes a phlegm somewhat acid, a little empyreumatic oil, and then volatile alkali both concrete and liquid. There remains in the retort a coaly, light, and spongy matter.

ANALYSIS OF CRUCIFORM PLANTS.

There is a class of plants called *cruciform*, because their flowers are disposed in a cross. These on an analysis furnish substances similar to

to those yielded by animal matters. Of this kind are cress, radish, scurvy-grass, mustard, and the other antiscorbutic plants.

These plants, distilled in a retort, give out a volatile alkali both concrete and liquid, and an empyreumatic oil. The residuum is a coaly matter.

Chemists are not yet agreed concerning the nature of the acrid principle of the antiscorbutic plants. It is certain that this principle, when obtained by a degree of heat inferior or equal to that of boiling water, is neither acid nor alkaline; at least nothing is perceived that indicates its partaking of the nature of either of these.

I am inclined to think that this principle is nothing else than phlogiston, which is in a state approaching to that in which it exists in the oily substance that composes the *spiritus rector* of odorous vegetables.

My conjecture is founded on the singular property which the antiscorbutic plants have of tanning

nishing silver vessels extremely, in the same manner as those saline matters do which contain a superabundance of phlogiston. Silver vessels tarnished by these plants are also as difficult to clean, or more so, than when tarnished by saline matters.

O N T H E

A N I M A L K I N G D O M.

ANIMAL substances are much more compounded than those we have hitherto examined. Several of the substances furnished by animals still preserve many of the properties of the vegetables by which they are nourished.

O N M I L K.

Milk is a white liquor which may be compared to emulsions, and is, in fact, an animal emulsion. Milk is compounded of butter, cheese, and phlegm which holds in solution a certain quantity of salts of different natures. This phlegm is termed *whey*.

Cheese acts as a mucilage in milk : it serves as a medium to unite the butter with the whey.
The

The butter contained in milk is in a state of extreme division, and gives it its white colour.

Acids coagulate milk, and separate it into two parts : one, which is the *curd* or cheese, is named the *caseous* part ; the other, which is the *whey*, is named the *serous* part.

Fixed alkali divides the caseous part of milk, and seems to dissolve it ; but in little while, it is found to coagulate it, as acids do.

FRANGIPANE.

Milk, distilled in a water-bath, yields a great quantity of insipid water. There remains at the bottom of the alembic the caseous part dried, which is the substance named *frangipane*.

ANALYSIS OF MILK.

When milk is set to rest, there forms at the surface a thick pellicle called *cream* : it is this that contains the butter.

Milk from which the cream is separated is less white and thick. When left quiet, it grows
four

four and curdles in a short time. The caseous part of this skimmed milk is cheese, which is separated from the whey by means of a cloth.

ANALYSIS OF CREAM.

Cream contains all the principles of milk, but in different proportions. It contains less water and less cheese than an equal measure of milk, but more butter. The cheese contained in cream is not in sufficient quantity to keep the butter suspended in the water; for which reason the butter separates from the other parts on agitating the cream.

The butter of cream may equally be separated by warming it in a water-bath; but the butter thus procured has the taste of melted butter, and is not so good as that got by agitation.

ANALYSIS OF BUTTER.

Butter yields, on distillation, a small quantity of an aqueous, acid, volatile, very penetrating liquor; and an oil in great abundance, which is of a somewhat thinner consistence than
the

the butter itself. The residuum is a very small quantity of coaly matter.

From this analysis it appears, that butter contains the same principles as vegetable oils, and that it is itself an oily vegetable substance, which has not changed its nature in passing into an animal body.

ANALYSIS OF CHEESE.

The cheese that ought to be the subject of an analysis, is that made from skimmed milk, which should also be boiled in water in order entirely to deprive it of butter. These precautions are necessary for an exact analysis. Cheese, thus prepared, yields a good deal of concrete volatile alkali, and of empyreumatic oil. There remains in the retort a considerable portion of a very rarefied coaly matter.

From this analysis it appears that cheese is a substance perfectly animalised, since it furnishes the same principles as really animal matters.

ANALYSIS OF WHEY, TAKING THAT OF COW'S MILK FOR AN EXAMPLE.

Whey, after three fourths of it are evaporated, yields at first a salt which has a sweet
fugary

fugary taste, and is therefore called *salt* or *sugar of milk*. This salt is obtained by the first crystallization. The most concentrated acids have no action upon it. It is, however, of a saponaceous nature. If it be exposed to the action of fire in a retort, an empyreumatic oil is expelled from it, and a fixed alkaline salt remains in the retort. Sugar of milk has many properties in common with cream of tartar, but differs from it in not being acid.*

On evaporating the remaining liquor afresh, it yields by crystallization a salt nearly similar to the preceding, but which is decomposed by the mineral acids. A third evaporation gives crystals of common sea-salt.

There remains at last a liquor which refuses to crystallize. It contains fixed alkali and a little extractive matter. The alkali is procured without combustion.

Every quart of cow's whey contains about seven or eight drams of the above-mentioned salts.

* Mr. Scheele has extracted from milk two kinds of acids; the one he calls the acid of milk, and the other the saccharine acid of milk. M.

It may reasonably be conjectured that all these salts come originally from the vegetables on which the animal feeds, and which have not been changed in their passage through the animal body.

ANALYSIS OF FLESH, TAKING BEEF FOR AN EXAMPLE.

Beef, submitted to distillation, yields, in the heat of boiling water, an insipid phlegm, which has a slight smell of meat. In a stronger heat it gives out a volatile alkali both concrete and fluid, and finally a very fetid empyreumatic oil. The residuum is a light spongy coal, which occupies a great space.

All kinds of flesh afford the same products, as well as all really animalised matters.

ANALYSIS OF SUET.

Mutton suet, submitted to distillation, yields a little of a very sharp penetrating acid liquor, and then an oil which congeals on cooling, and which has nearly the same consistence that the suet had before. A great number of repeated distillations are necessary for obtaining a fluid oil. After the distillation and rectification of suet,

fuet, there remains a small quantity of coaly matter.

From this analysis it appears, that fuet and all fatty animal matters afford the same principles with vegetable oils.

ANALYSIS OF OSSEOUS MATTERS, TAKING
HARTSHORN FOR AN EXAMPLE.

Hartshorn, with a heat a little greater than that of boiling water, gives out a large quantity of an insipid phlegm, with a faint very disagreeable smell. In a stronger fire it yields a phlegm charged with volatile alkali, which is called *volatile spirit of hartshorn*; then a little of a light but fetid oil, a concrete volatile alkali, a red oil, and an oil as thick as turpentine. These three oils are confounded together, and are extremely fetid.

There remains in the retort the pieces of hartshorn, which are black, and in a coaly state, but have preserved their form.

Bones and osseous matters are composed of a good deal of earth, and a gelatinous perfectly
animalised

animalised matter, which serves as a glue to bind together the osseous particles, and give consistence to the bones. It is this substance alone which yields the products above-mentioned on an analysis.

The products are rectified, in order to have them in their greatest purity.

VOLATILE SPIRIT OF HARTSHORN RECTIFIED.

Volatile spirit of hartshorn is of a red colour, owing to a little oil that it holds in solution. On distilling it, there rises, with a heat much below that of boiling water, volatile alkali in a concrete form. This salt is clean and transparent: it lines the upper part of the vessel. It dissolves in the liquor which rises after it; and this forms *rectified volatile spirit of hartshorn*.

When about half the liquor is come over, what remains in the retort is a phlegm of a bad smell, which contains no more volatile alkali. It is thrown away as useless.

RECTIFICATION OF VOLATILE SALT OF HARTSHORN.

Volatile salt of hartshorn is of a black colour, owing to a portion of fetid oil with which
it

it is impregnated. It is submitted to distillation several times successively, mixing it with absorbent earths and sand, in order to retain the oily matter.

RECTIFICATION OF OIL OF HARTSHORN.

DIPPEL'S ANIMAL OIL.

On submitting the fetid oil of hartshorn to distillation, it is rectified, becomes white and fluid like spirit of wine, and loses almost all its bad smell. This is what is called *Dippel's animal oil*. The fetid oil must be distilled three or four times for this purpose. A good deal of coaly matter remains after each distillation.

CALCINED HARTSHORN.

The hartshorn remaining in the retort after the first operation is black, on account of the coal of the gelatinous part which it contains.

This is burned in the open air in order to destroy the coaly matter. After that there remains only a white earth, which has some properties in common with vitrifiable and calcareous earths :

earths: it in some measure holds the middle place between these earths, but is not a calcareous earth, as some chemists have thought. It is not converted into quicklime by calcination.*

HARTSHORN PREPARED PHILOSOPHICALLY WITH WATER.

When hartshorn cut in pieces is boiled in a good quantity of water, the cartilaginous part dissolves in great measure in the water, but the earthy part preserves its form. These pieces have not near the same solidity they before had, because there remains only, in a manner, the pure earth, deprived of the gelatinous part. In the following experiment the inverse of this is performed, that is, the earth of bones is separated, and the cartilage preserved by itself.

DECOMPOSITION OF BONES BY ACIDS.

A flat piece of ivory or hartshorn is plunged into diluted nitrous acid. The acid dissolves

* By numberless experiments, it has lately been proved, in consequence of some disputes amongst the French chemists, that the earthy basis of hartshorn and other bony substances is almost wholly calcareous. M.

all the earth, but does not touch the cartilage; and the piece preserves its form entire. It is washed in a somewhat alkaline liquor, in order to carry off all the acid. In drying it becomes transparent and flexible like horn.

PRECIPITATION OF THE EARTH OF BONES
BY FIXED ALKALI.

On pouring fixed alkali into the acid in which bone has been infused, it unites with the acid, and throws down the earth.

ON EGGS.

Eggs are composed of an earthy covering, which is the *shell*; a mucilage within it called the *white*; and a yellow globe in the centre of the white, named the *yolk*. These three substances differ much in their nature.

The yolk is the part which is to form the chick; the white is the part which is to serve it for nourishment during incubation, and in proportion as the chick discloses itself.

The

The shell is a calcareous earth, which dissolves in acids with a brisk effervescence, and is converted into quicklime by calcination.

ANALYSIS OF WHITE OF EGG.

White of egg, in the heat of boiling water, yields a great quantity of insipid water. The dry residuum is transparent as horn.

This matter, submitted to distillation with a superior degree of heat, yields a good deal of concrete volatile alkali, and a little empyreumatic oil.

ANALYSIS OF YOLK OF EGG.

Yolk of egg is composed of a very soft oil, and a mucilaginous matter which may be considered as destined to form the solid parts of the chick. These two substances are of a different nature, as we shall presently see.

EMULSION OF YOLK OF EGG.

Yolk of egg diffuses in water, and forms a white liquor resembling an emulsion; or rather which is a real animal emulsion.

The mucilaginous matter serves as a medium to unite the oil with the water.

OIL OF YOLK OF EGG.

When yolks of eggs are dried, they liquefy after losing their humidity. If in this state they are submitted to the press, a very soft yellow oil is procured, called *oil of eggs*.

Oil of eggs submitted to distillation, yields a very volatile, very penetrating acid, and an oil of the same nature, that is, acid.

From this analysis it appears, that yolk of egg preserves all the properties of the vegetable oils to which it owes its origin.

The residuum after the expression of oil of eggs is of a very different nature. It is a perfectly animalised substance. It yields, on an analysis, volatile alkali, as the flesh of animals does, and a good deal of empyreumatic oil.

COAGULATION OF WHITE OF EGG BY SPIRIT OF WINE.

White of egg diffuses in water like mucilaginous matters. If spirit of wine be added to this

this mixture, it unites to the water, and the white of egg coagulates and separates.

ANALYSIS OF FAT.

The fat of animals is absolutely of the same nature with their suet. It yields the same principles on an analysis; that is, a very volatile and penetrating acid, and a thick oil, which fixes on cooling.

ANALYSIS OF URINE.

Urine is an excrementitious liquor, charged with the superabundant salts of the animal œconomy.

The fresh urine of persons in good health neither effervesces with acids nor alkalies.

Fixed alkali causes it to exhale an odour of volatile alkali.

The urine of some persons in perfect health turns syrup of violets green; and the urine of others turns the tincture of turnsole red: those who make urine of this latter quality are less subject to the stone and gravel, but it is always

a sign of bad digestion, since it shews that the vegetable acids have not been sufficiently elaborated.

DISTILLATION OF URINE.

Urine, in a heat below that of boiling water, yields a clear liquor, of a very disagreeable smell, and which is found to contain nothing saline.

In the heat of boiling water, the fluid that comes over is charged with a little volatile salt, and turns syrup of violets green.

FUSIBLE SALT OF URINE.

Urine evaporated two thirds, yields, on cooling, a salt of a particular nature, which is called *native salt*, or *fusible salt of urine*. This is the only kind of salt in urine proper for making the phosphorus of which we are soon to speak.

SEA-SALT EXTRACTED FROM URINE.

On continuing the evaporations and crystallizations of urine, sea-salt is procured, and the other mineral neutral salts which men sometimes
make

make use of, or are contained in the substances which compose their food.

EXTRACT OF URINE.

After the crystallization of the salts of urine, there remains a red thick liquor, which evaporated to dryness, yields the *extract of urine*.

EXAMINATION OF THE FUSIBLE SALT OF URINE.

This salt impresses the tongue with a saline, somewhat cool taste.

It does not lose its water of crystallization in the air. It froths in the fire, and by a sufficient degree of heat is reduced to a transparent glass, as borax is.

The fusible salt of urine is an ammoniacal salt of a particular nature. It is composed of volatile alkali and an acid named *phosphoric acid*. This acid is in the highest degree fixed in the fire.

The fusible salt of urine submitted to distillation suffers the volatile alkali to escape: the acid is left behind in the retort, not being capable of rising.

This acid has all the general properties of acids. When united to the phlogiston it forms a kind of sulphur, named *phosphorus*.

This phosphorus is generally made in the following manner.

PHOSPHORUS.

A mixture is made of plumbum corneum, of urine dried to the consistence of an extract (from which the fusible salt has not been separated,) and of charcoal in powder. This is submitted to distillation with a gradual heat.

There first rises volatile alkali, partly concrete, and partly fluid, and a very fetid empyreumatic oil. The fire is raised till the retort becomes red, and nothing more comes over. The receiver is then changed; water is put into the new one, and the fire is increased till the retort is brought to a white heat. The phosphorus passes over in vapours, and manifests itself by
the

the light which spreads through the inside of the receiver, and which issues through the little hole made in its body.

When the operation is finished, the vessels are suffered to cool during forty-eight hours. At the bottom of the receiver there is found a black coaly powder which contains the phosphorus.

The above process is that of Mr. Margraff. It has always succeeded with me, not failing once in twenty times that I have tried it. Some persons would insinuate that the plumbum corneum causes the retorts to melt during the operation; but I can affirm the contrary. This mixture is so refractory that it does not even enter into fusion in a crucible, on account of the charcoal, which prevents the re-union of the lead that revives in extremely minute grains.*

* The chemical world is much obliged to Mr. Scheele for the simple method by which this singular body is now procured. The bones of all quadrupeds, of birds, and fishes, by long digestion in the vitriolic acid yield microcosmic salt in great abundance; and the union of this salt with an equal weight of charcoal, affords by distillation a considerable quantity of phosphorus. M.

RECTIFICATION OF PHOSPHORUS.

The coaly powder above-mentioned is submitted to distillation. The phosphorus, which exists in it ready formed, rises with a moderate heat. Water must be put into the receiver to prevent the phosphorus from burning as it comes over.

In order to form the phosphorus into sticks, it is melted in tubes of glass filled with water and stopped with a cork at the lower end. These tubes are plunged into hot water, when the phosphorus melts and settles into the lower part of the tubes. When it has cooled and fixed it is drawn from the tubes, and kept in bottles filled with water, because it decomposes in the air.

Phosphorus smokes in a warm air : the phlogiston flies off, and the acid remains.

It inflames with a very moderate degree of heat; for this purpose it is sufficient to rub it between two papers. When melted in water heated to 50 degrees above the freezing point by
Reaumur's

Reaumur's thermometer, it swims and inflames on the surface of the water.

ANALYSIS OF ANTS.

Ants, common flies, bees, and many other insects of this kind, submitted to distillation, yield an acid and an empyreumatic oil, like vegetable matters. After these substances are extracted, a volatile alkali and an empyreumatic oil of the same nature, that is, similar to those procured from perfectly animalised matters, come over. There remains in the retort a light spongy coal.

ANALYSIS OF SPONGES.

Sponges, madrepores, corals, and other receptacles of marine insects, yield, on distillation, the same products as animalised matters; that is, volatile alkali and a fetid oil of the same nature.

O N

D Y I N G.

THE art of dying is entirely founded on chemistry. To dye a substance is to combine it with one or more substances of an absolutely different nature. The operations by which these combinations are made afford an infinite number of very singular and interesting chemical phenomena. This it was that engaged Mr. Macquer to occupy himself with this object, and to make it the subject of one of our chemical lectures. An abstract will probably be acceptable to the reader.

All the art of dying consists, in extracting the colouring matters from the different bodies that contain them, making them pass into the
substances

substances that are to be dyed, and fixing them there as firmly as possible.

The colouring matters made use of in dying are extracted from vegetables and animals. Mr. Macquer, in consequence of the experiments he has made relative to this subject, has ranged them all in three classes; viz. 1. dyes of a gummy nature; 2. those which are gummy-refinous; 3. those which are purely refinous.

Among these substances there are some which serve for dying without any preparation or *corrosive*. These are those the dying principle of which is of the nature of gummy-refins.

Those substances the dying principle of which is refinous, require a preparation, in order to facilitate its solution in water, and exalt its colour. They, however, require no particular preparation of the stuff to be dyed.

Those, the colouring principle of which is of a gummy nature, require a corrosive, in order to make the colour adhere better, and to exalt it. Among the dyes of this class, there are some
the

the corrosive of which is put into the stuff before the application of the colouring matter, and others where it is put into the vat containing the dye.

The matters to be dyed afford particular phenomena, which are relative to their specific nature and character. Wool, silk, cotton and thread are not equally susceptible of receiving the same dyes. Wool and animal matters are those which are the most easily dyed, and the colours of which are the finest and most durable: cotton, thread and all vegetable matters, on the other hand, are more difficult to be dyed. Silk holds the middle rank, not being so easily dyed as animal, nor so difficultly as vegetable matters. We shall give some examples of the different classes we have just established.

ON GUMMY-RESINOUS DYES, WHICH REQUIRE NO PREPARATION NOR CORROSIVE.

Any quantity desired of green walnut shells is boiled in water, and the decoction strained. Into this liquor, which is called a *bath*, is plunged a skain of wool, and it is left there till sufficiently

sufficiently dyed. The wool is then washed several times, in order to take off all the dye which is not incorporated with the stuff.

The *proof* of this dye is a solution of cream of tartar in water.

By the term *proof*, is meant the experiment made to try the firmness of a dye applied to any stuff. This experiment consists in boiling the dyed stuff, for a certain time, in water charged with substances, the action of which that dye ought to resist. The proof is therefore different, according to the nature of stuffs and dyes.

On Resinous Dyes which require being prepared, but need no Preparation of the Stuff.

ROSE-COLOURED DYE, GOT FROM CARTHAMUS.

Two drams of carthamus washed and dried* are mixed with eighteen grains of alkaline salt,
and

* The flower of carthamus, or bastard saffron, contains a great quantity of yellow extractive matter, soluble in water,
which

and seven drams of spirit of wine. This mixture is macerated in the cold for two hours: two ounces of cold water are then added, and it is macerated two hours more. The liquor is passed through a cloth, and a sufficient quantity of lemon juice or distilled vinegar is put to it, till it becomes of a cherry colour. This *bath* is used for dying silk.

which must be taken out before the flower is used for a red dye. Flowers of carthamus are washed in the following manner. Some pounds of it are put into a cloth sack, moderately tight. This is put in water, and worked about with the hands, to facilitate the solution of the extractive matter. The water is changed in proportion as it becomes impregnated, and thrown away as useless. The operation is continued, till the water is no longer discoloured. The dyers are accustomed to use it while it is moist, as they have remarked that it does not afford colour enough when suffered to dry. But this lotion would be very inconvenient in operating in the small way, because fresh carthamus must be washed as often as it was wanted. I have remarked that it may be dried, and yet used at pleasure, on moistening it with a little spirit of wine, which dissolves the resinous colouring part. Carthamus, thus dried, gives out its dye copiously enough for small operations.

ANOTHER

ANOTHER EXAMPLE.

SAXON BLUE.

Three drams of indigo and an ounce and a half of concentrated vitriolic acid are digested together with a gentle heat. To this mixture a small quantity of water is added.

When this indigo is wanted for use, a little of it is diffused in a good deal of boiling water. Into this liquor the stuff to be dyed is plunged, and kept in till it has acquired sufficient colour.

The proof of this dye is vinegar.

On Gummy Dyes, which require a Corrosive of Alum.

YELLOW OF YELLOW WOOD.

Three drams of yellow wood cut in small pieces are boiled in eight ounces of water, and the decoction strained. Into this a skain of alumed * silk is plunged, while it is very hot, and is left in till sufficiently coloured.

* To alum, is to impregnate a stuff with alum. For this purpose, alum is dissolved in water, and the stuffs are plunged in the solution, where they are kept for a certain time. They are then washed to take off all the superfluous alum.

It

It is necessary that the alumed silk should be well washed before it is dipped into the liquor, otherwise the superabundant portion of alum which is not combined with the silk, will precipitate all the colour of the dye in clots.

ANOTHER EXAMPLE.

FINE CRIMSON.

A decoction is made of a dram of cochineal in four ounces of water, and six drops of solution of tin in aqua regia are added. Into this a skain of alumed silk is dipped, which in a short time is dyed a fine crimson.

The proof of this dye is soap-water.

On Gummy Dyes, the Corrosive of which is put into the Liquor.

SCARLET ON WOOL.

Half a dram of cochineal is boiled in eight ounces of water, and to this is added a dram of solution of tin in aqua regia, let down with as much water. A piece of woollen stuff is plunged into this bath, and boiled till it is sufficiently coloured.

The

The proof of this dye is solution of alum.

Thread, cotton and silk do not take this dye.

After these processes for dying, I shall give a receipt for a very good writing ink, which, it is well known, is the basis of the black dye; and I shall conclude with a process for making *painter's lake*.

I N K.

Take of galls, a pound; gum Arabic, six ounces; green vitriol, six ounces; water, seven pints.

The galls and gum Arabic are to be grossly pounded, and macerated in the water, upon warm ashes, for twelve hours, stirring the matter from time to time with a stick. The green vitriol is then to be added; and, while the mixture is pretty hot, the whole is to be stirred, without putting it again on the fire. When the liquor is cooled, the ink is made. It is passed through a hair sieve, and suffered to settle till the next day. It is then put into well-stopped bottles.

Galls contain an astringent principle, and developed phlogiston. These principles decompose

pose the vitriol. The phlogistic matter attacks the iron, precipitates it, and converts it into a matter very analogous to Prussian blue, but differing from it in being entirely soluble in acids, which the other is not. This ferruginous precipitate is very fine. It would fall down after some time, if it were not supported by the mucilage of the gum Arabic, which gives the liquor sufficient consistence to retain it.

RED LAKE OF COCHINEAL.

Half an ounce of cochineal and five ounces of alum are boiled together in a sufficient quantity of water. The liquor is filtered, and some drops of solution of tin are poured into it. Some fixed alkali in solution is then added. This decomposes the alum, and precipitates its earth; which, as it falls down, collects and carries with it all the red colour. The liquor is filtered; the fluid is thrown away, and the precipitate is washed to carry off the saline particles, and then dried.

All the other lakes may be prepared in the same manner. The solution of tin may be left out if it be thought proper.

I N D E X.

A.

A <i>CID Marine</i>	Page 102
—— got from powder of Algaroth	211
—— smoking	106
—— <i>Nitrous</i>	92
—— mixed with water	93
—— smoking, made with colcothar	155
—— of honey	302
—— of petroleum	296
—— of turpentine	292
—— <i>Phosphoric</i>	361
—— <i>Universal</i>	64
—— <i>Vitriolic</i>	65
—— changes the colour of the vapours of nitrous acid	100
—— coloured by oily matters	67
—— concentrated or rectified	<i>ibid.</i>
—— extracted from sulphur	86
—— dephlogisticated by nitrous acid	100
<i>Acid,</i>	

<i>Acid, Vitriolic</i> , effects of on vitrifiable earths	Page 70
————— extracted from alum	74
————— icy	91, 154
————— sulphureous	68, 305
————— sulphureous volatile	86
<i>Æther, Acetous</i>	327
————— <i>Marine</i>	310
————— <i>Nitrous</i>	308
————— <i>Vitriolic</i>	305
<i>Æthiops, Mineral</i>	191
<i>Affinity</i> , what	3
————— different species of	6
————— tables of	5
<i>Aggregate, Aggregation</i>	2
<i>Air</i> , on	39
————— different states of	40
————— the vehicle of combustion	45
<i>Alcohol</i> of Boerhaave, what	31
<i>Alkali, fixed</i> , on	78
————— rendered caustic by quicklime	79
————— <i>phlogisticated</i>	166
————— ————— lye of	<i>ibid.</i>
————— saturated with the colouring matter of	
Prussian blue	171
————— <i>volatile</i> , on	332
<i>Alum</i> , on	70
————— <i>artificial</i>	81
————— <i>calcined</i>	73
	<i>Alum,</i>

<i>Alum</i> , crystalization of	Page	73
— decomposed by calcareous earths	-	72
— extracted from pyrites	-	223
— phlegm of	-	73
— saturated with its earth	-	71
<i>Amalgam</i> of mercury and gold	-	194
— — — — — and silver	-	<i>ibid.</i>
— — — — — and tin	-	195
<i>Amber</i> , analysis of	-	297
— varnish	-	<i>ibid.</i>
<i>Amethyst</i> , false	-	255
<i>Ammoniacal</i> salt, nitrous	-	333
— — — — — vitriolic	-	332
— — — — — salts decomposed by absorbent earths	-	335
— — — — — by fixed alkali	-	334
— — — — — by quicklime	-	336
<i>Analysis</i> of bodies, what	-	2
<i>Animal</i> kingdom, on the	-	346
— matters stained by solution of gold	-	125
— — — — — of silver	-	132
— oil, Dippel's	-	354
<i>Antimoniated</i> nitre	-	207
— — — — — saffron of Mars	-	201
<i>Antimony</i> , on	-	197
— — — — — diaphoretic	-	207
— — — — — flowers of	-	197
— — — — — glass of	-	204
— — — — — grey calx of	-	203

Ants,

<i>Ants, analysis of</i>	-	Page 365
<i>Aqua Cœlestis</i>	-	342
— <i>Fortis</i> precipitated	-	132
— <i>Regia</i>	-	334
<i>Arbor Dianæ</i>	-	195
<i>Arsenic, on</i>	-	216
— dissolved in water	-	217
— effects of mineral acids on	-	<i>ibid.</i>
— extracted from cobalt ore	-	230
— mixture of with tin	-	220
<i>Azure blue</i>	-	231

B.

<i>Balsam of sulphur with essential oils</i>	-	287
— — — — — with fatty oils	-	282
— — — — — of turpentine	-	293
<i>Balsams, analysis of</i>	-	292
<i>Becher, his theory of principles</i>	-	16
<i>Benzoin, analysis of</i>	-	294
<i>Bezoar, mineral</i>	-	212
<i>Bismuth, on</i>	-	<i>ibid.</i>
— crystals of	-	213
— extracted from cobalt ore	-	232
— magistery of	-	214
— solution of in nitrous acid	-	213
<i>Bittern</i>	-	263
<i>Bitumens, on</i>	-	296
<i>Blue</i>		

<i>Blue</i> colour disappearing for want of air	Page	342
<i>Bones</i> , decomposed by acids	-	355
— earth of, precipitated	-	356
<i>Borax</i> , on	-	111
— calcined	-	112
— glafs of	-	113
— regenerated	-	117
<i>Brandy</i>	-	304
<i>Brass</i>	-	216
<i>Bronze</i>	-	149
<i>Butter</i> , analysis of	-	348
— of antimony	-	209
— dissolved in marine acid	-	211
— in nitrous acid	-	<i>ibid.</i>
— of tin	-	193

C.

<i>Calcareous Earths</i> , on	-	244
<i>Camphor</i> , on	-	295
— oil of	-	<i>ibid.</i>
<i>Carthamus</i> , preparation of	-	369
<i>Cassius's</i> golden precipitate	-	148
<i>Caustic Stone</i>	-	105
<i>Cerufs</i>	-	328
<i>Cheese</i> , analysis of	-	349
<i>Chemical</i> composition, what	-	3
— decomposition, what	-	2

R

Chemistry,

<i>Chemistry</i> , definition of	-	-	Page 1
<i>Cinnabar</i> , artificial	-	-	192
—— of antimony	-	-	210
<i>Clays</i> , on	-	-	243
<i>Cliffus</i> of nitre	-	-	96
<i>Cobalt Ore</i> , calcination of	-	-	231
<i>Colcothar</i>	-	-	154
—— salt of	-	-	155
<i>Cold</i> , its effects	-	-	22
<i>Combination</i> , what	-	-	3
<i>Combustible bodies</i> , what	-	-	29
<i>Compound bodies</i> , what	-	-	3
<i>Compounds</i> according to Stahl	-	-	14
<i>Constituent parts</i> , what	-	-	3
<i>Copper</i> , on	-	-	135
—— calcined by nitre	-	-	142
—— in the air	-	-	137
—— calxes of, reduced	-	-	<i>ibid.</i>
—— destroyed by water	-	-	138
—— flowers of	-	-	136
—— glafs of	-	-	137
—— precipitated by absorbent earth	-	-	141
—— by fixed alkali	-	-	142
—— by iron	-	-	163
—— scales of	-	-	136
—— solution of in aqua regia	-	-	140
—— in marine acid	-	-	<i>ibid.</i>
—— in nitrous acid	-	-	139
—— in vitriolic acid	-	-	138

Copper,

<i>Copper</i> , vitriol of	-	-	Page <i>ibid.</i>
— whitened by mercury	-	-	185
<i>Corrosive sublimate</i>	-	-	188
— caput mortuum of	-	-	<i>ibid.</i>
— decomposed by fixed alkali	-	-	191
<i>Cream</i> , analysis of	-	-	348
<i>Cruciform Plants</i> , analysis of	-	-	343
<i>Crystal</i> , or glass	-	-	80
— <i>Mineral</i>	-	-	95
<i>Cristalization</i> of salts	-	-	74
<i>Cupellation</i> of silver by lead	-	-	178

D.

<i>Delft-ware</i>	-	-	249
<i>Dye</i> , crimson	-	-	372
— rose-coloured	-	-	369
— scarlet on wool	-	-	372
— yellow, of yellow-wood	-	-	371
<i>Dyes</i> , gummy	-	-	371, 372
— gummy-resinous	-	-	368
— resinous	-	-	369
<i>Dying</i> , on	-	-	366

E.

<i>Earth</i> , on	-	-	51
— different species of	-	-	53
R 2	-	-	<i>Earth</i> ,

<i>Earth</i> , elementary	-	-	Page 52
—— separated from liquor of flints	-	-	81
<i>Earths</i> , calcareous	-	-	55
—— fusion of by one another	-	-	247
—— vitrifiable	-	-	54
<i>Earthy Substances</i> , on	-	-	241
<i>Eau de Luce</i>	-	-	343
<i>Eggs</i> , on	-	-	356
—— white of, analysis of	-	-	357
—— ——— coagulation of by spirit of wine	-	-	358
—— yolk of, analysis of	-	-	357
—— ——— emulsion of	-	-	<i>ibid.</i>
—— ——— oil of	-	-	358
<i>Elements</i> of bodies, what	-	-	11, 14
<i>Emerald</i> , false	-	-	254
<i>Emulsions</i> ,	-	-	282
<i>Enamel</i> , coloured	-	-	256
—— white	-	-	177, 255
<i>Ens Martis</i>	-	-	341
—— <i>Veneris</i>	-	-	143, 341
<i>Exhausted Plants</i> , what	-	-	284
<i>Extracts</i> of Vegetables	-	-	<i>ibid.</i>

F.

<i>Fat</i> , analysis of	-	-	359
<i>Fermentation</i> , on	-	-	303
—— acid	-	-	321
—— spirituous	-	-	303
			<i>Fire,</i>

<i>Fire</i> , on	-	-	Page 18
causes exciting	-	-	27
combined with bodies	-	-	29
effects of on air	-	-	42
penetrability of	-	-	22
signs of the presence of	-	-	20
whether weighty or no	-	-	26
<i>Flesh</i> , analysis of	-	-	351
<i>Flux</i> , black	-	-	318
crude or white	-	-	317
<i>Frangipane</i>	-	-	347
<i>Fulminating Gold</i>	-	-	340
<i>Powder</i>	-	-	102
<i>Furnaces</i> , on	-	-	47
of baked earth	-	-	250

G.

<i>Garnet</i> , false	-	-	254
<i>Gas</i> , in mineral waters	-	-	260
<i>Girasole</i> , Venetian	-	-	255
<i>Glass</i> , or crystal	-	-	80
acted upon by acids	-	-	251
blue	-	-	234
of borax	-	-	113
of wine bottles	-	-	251
white	-	-	252
<i>Glazed Earth</i>	-	-	249
<i>Gold</i> , on	-	-	123

<i>Gold</i> alloyed with platina, means of discovering	128
— and silver for parting	133
— crystals of	125
— dissolved by aqua regia	124
— by liver of sulphur	126
— fulminating	340
— fusion of	124
— in rags	125
— precipitated by fixed alkali	<i>ibid.</i>
— from liver of sulphur	126
— purified by antimony	202
<i>Golden precipitate of Cassius</i>	148
— sulphur of antimony	199
<i>Guaiacum Wood</i> , analysis of	288
<i>Gums</i> , on	299
— analysis of	300
— precipitated from water by spirit of wine	315
<i>Gummy-resins</i> , on	300
— analysis of	301
<i>Gun-powder</i>	101
— decomposition of	<i>ibid.</i>
<i>Gypsum</i> , on	69, 245
— prepared, or platter	70

H.

<i>Hartsborn</i> , analysis of	352
— calcined	354
— oil of, rectified	<i>ibid.</i>
<i>Hartsborn</i> ,	

<i>Hartsborn</i> prepared philosophically	Page 355
———— volatile salt of, rectified	- 353
———— volatile spirit of, rectified	- <i>ibid.</i>
<i>Honey</i> , analysis of	- 302
<i>Hyacinth</i> , false	- 254

I.

<i>Jalap</i> , analysis of	- 312
<i>Inflammable Principle</i> , what	- 31
<i>Ink</i>	- 373
<i>Integrand Parts</i> , what	- 3
<i>Iron</i> , on	- 150
———— calcined by nitre	- 163
———— dissolved by aqua regia	- <i>ibid.</i>
———— by marine acid	- 162
———— by nitrous acid	- 160
———— by vitriolic acid	- 152
———— melted by sulphur	- 159
———— precipitated by itself	- 161
———— revived without fusion	- 158
———— separated from martial vitriol	- 157
———— white	- 165
<i>Juices of plants</i> , on	- 274
———— clarification of	- <i>ibid.</i>

K.

<i>Kermes Mineral</i> by fusion	- 205
———— the moist way	- <i>ibid.</i>

L.

<i>Lake</i> , red of cochineal	-	Page 374
<i>Lamp-black</i>	-	294
<i>Lapis Infernalis</i>	-	131
<i>Lead</i> , on	-	172
— artificial ore of	-	177
— calcined by nitre	-	<i>ibid.</i>
— calx of	-	172
— combined with sulphur	-	177
— glass of	-	174
— magistery of	-	176
— reduction of calx and glass of	-	174
— solution of in nitrous acid	-	<i>ibid.</i>
— vitriol of	-	175
— white	-	328
<i>Lilium of Paracelsus</i>	-	311
<i>Lime</i> , milk of	-	60
— oil of	-	339
— paste of	-	59
— pellicles or cream of	-	61
— flaked in the air	-	59
— water	-	60
<i>Liquor of Flints</i>	-	81
— smoking of Libavius	-	193
<i>Litharge</i>	-	173
<i>Liver of Antimony</i>	-	204
— of sulphur	-	88
— — — — — artificial	-	89
		<i>Luna</i>

<i>Luna Cornea</i>	-	-	Page 132
<i>Lunar Crystals</i>	-	-	130
— <i>Vitriol</i>	-	-	131

M.

<i>Magistery of bismuth</i>	-	-	214
— of crab's eyes	-	-	324
— of lead	-	-	176
— of sulphur	-	-	88
<i>Magnesia Alba</i>	-	-	270
— of sea-salt	-	-	263
<i>Mars, balls of</i>	-	-	320
— tincture of	-	-	<i>ibid.</i>
<i>Martial Æthiops</i>	-	-	152
— alkaline tincture	-	-	161
<i>Massicot</i>	-	-	173
<i>Materia Perlata</i>	-	-	208
<i>Mechanical Division, what</i>	-	-	I
<i>Mercurial Nitre</i>	-	-	184
— <i>Panacea</i>	-	-	190
<i>Mercurius Dulcis</i>	-	-	189
<i>Mercury, on</i>	-	-	180
— congelation of	-	-	181
— precipitated per se	-	-	182
— from nitrous acid by fixed			
alkali	-	-	187
— red precipitate of	-	-	185
— revived from cinnabar	-	-	192
— from corrosive sublimate	-	-	194, 209
	R 5		<i>Mercury,</i>

<i>Mercury</i> , solution of in distilled vinegar	Page	330
———— of in nitrous acid	-	185
———— vitriol of	-	183
———— white precipitate of	-	187, 342
———— yellow precipitate of by fixed alkali	-	183
<i>Metallic Substances</i> , on	-	118
<i>Metals</i> , what	-	121
———— imperfect	-	122
———— perfect	-	121
<i>Milk</i> , on	-	346
———— analysis of	-	347
<i>Mineral Waters</i> , on	-	257
<i>Minium</i>	-	173
<i>Mixture</i> , according to Stahl	-	3
<i>Mortar of Lime and Sand</i>	-	62
<i>Mother-Water of Nitre</i>	-	270
<i>Mucilages</i> , on	-	282

N.

<i>Nitre</i> , on	-	269
<i>Nitre</i> , alkalised by arsenic	-	219
———— without addition	-	95
———— decomposed by arsenic	-	218
———— by clays	-	98
———— detonation of by amber	-	297
———— extracted from rubbish	-	269
———— fixed by charcoal	-	96
———— of two boilings	-	271

Nitre,

<i>Nitre</i> of three boilings	-	Page 272
— quadrangular	-	109
— regenerated	-	95
— with a fixed alkaline basis	-	94
— with an earthy basis	-	<i>ibid.</i>
— — — — — decomposition of		93, 94

O.

<i>Ochre</i> ,	-	153
<i>Oil</i> , animal, Dippel's	-	354
— of tartar	-	79
<i>Oils</i> , essential	-	283
— — — — inflammation of	-	285
— — — — rectification of	-	284
— — — — expressed	-	275
— — — — fatty	-	<i>ibid.</i>
— — — — combination of with vitriolic acid		276
— — — — inflammation of	-	<i>ibid.</i>
<i>Opal</i> , false	-	255
<i>Ores</i> , on	-	224
— of antimony	-	228
— — bismuth	-	<i>ibid.</i>
— — cobalt	-	229
— — copper	-	227
— — gold	-	225
— — iron	-	227
— — lead	-	226
— — mercury	-	229

Ores, of silver	-	-	Page 225
—— tin	-	-	227
—— zinc	-	-	228
Orpiment	-	-	218
Osseous Matters, analysis of	-	-	352

P.

Paracelsus, his theory of principles	-	-	15
Parting	-	-	134
Petroleum, analysis of	-	-	296
Phagædenic Water	-	-	190
Phlogiston, on the	-	-	34
—— of Stahl	-	-	32
Phosphorus	-	-	362
—— rectification of	-	-	364
Pitch	-	-	294
Plants, putrefied, analysis of	-	-	331
Plasters	-	-	283
Platina, on	-	-	126
—— exposed to the fire	-	-	127
—— precipitate of	-	-	<i>ibid.</i>
—— solution of	-	-	<i>ibid.</i>
Plumbum Corneum	-	-	176, 340
—— Ustum	-	-	177
Porcelain	-	-	250
—— of Reaumur	-	-	252
Pot-ash	-	-	291
Powder of algaroth	-	-	210

Prince's

<i>Prince's Metal</i>	-	-	Page 216
<i>Principles, what</i>	-	-	3
———— active and passive	-	-	15
———— primitive or elements	-	-	11, 14
———— secondary or mixts	-	-	13
<i>Proof of a dye, what</i>	-	-	369
<i>Prussian Blue</i>	-	-	165, 319
———— brightening	-	-	167
———— decomposition of	-	-	170
———— preparation of	-	-	166
———— theory of	-	-	167
———— without alum	-	-	170
<i>Putrefaction, on</i>	-	-	330
<i>Putty of tin</i>	-	-	144
<i>Pyrites, on</i>	-	-	220
———— fallen into efflorescence	-	-	222
<i>Pyrophorus</i>	-	-	90

Q.

<i>Quicklime</i>	-	-	58
------------------	---	---	----

R.

<i>Reagal</i>	-	-	218, 230
<i>Regulus of Antimony, on</i>	-	-	196
———— dissolved by aqua regia	-	-	208
———— made with calx	-	-	203
———— martial	-	-	200
———— separated from antimony	-	-	198
———— silvery flowers of	-	-	196
			<i>Regulus</i>

<i>Regulus of Arsenic</i>	-	-	Page 217
<i>Regulus of Cobalt, on</i>	-	-	233
_____ a kind of decomposition of			235
_____ calcined by nitre	-		236
_____ calx of	-		234
_____ combined with liver of sul			
phur	-	-	235
_____ dissolved in aqua regia			238
_____ in marine acid			<i>ibid.</i>
_____ in nitrous acid			237
_____ in vitriolic acid			236
_____ extracted from the ore	-		232
_____ precipitated by fixed alkali			237
<i>Resinous Matter, artificial</i>	-	-	276
<i>Rotrou's Solvent</i>	-	-	206
<i>Ruby, false</i>	-	-	254

S.

<i>Saccharine Juices, on</i>	-	-	301
<i>Saffron of Mars, aperient of Stahl</i>	-		162
_____ dissolved in nitrous acid			<i>ibid.</i>
_____ prepared by dew	-		151
_____ with sulphur	-		158
_____ Zwelfer's	-		151
<i>Sal Ammoniac</i>	-	-	333
_____ decomposition of by calx of lead			340
_____ by copper	-		341
_____ by iron	-		<i>ibid.</i>
_____ by vitriolic acid			333
			<i>Sal</i>

<i>Sal Polychrest of Glaſer</i>	-	Page 100
----- <i>of Rochelle</i>	-	319
<i>Saline Subſtances, on</i>	-	63
<i>Salt, Epfom</i>	-	265
----- <i>febrifuge of Silviuſ</i>	-	103
----- <i>fixed alkaline of vegetables</i>	-	289
----- <i>Tacheniuſ's</i>	-	290
----- <i>Glauber's</i>	-	107, 109
----- <i>decompoſed by ſalt of Saturn</i>	-	329
----- <i>fallen into efflorefcence</i>	-	108
----- <i>procured from Schlot</i>	-	264
----- <i>neutral, arſenical</i>	-	218
----- <i>of acid of turpentine</i>	-	287
----- <i>of colcothar</i>	-	155
<i>Salt of Jupiter</i>	-	147
----- <i>of pot-aſh</i>	-	292
----- <i>of Saturn</i>	-	329
----- <i>of Seignette</i>	-	319
----- <i>of ſoda</i>	-	291
----- <i>ſedative</i>	-	113, 114
----- <i>glafs of</i>	-	115
----- <i>ſolution of</i>	-	<i>ibid.</i>
----- <i>in ſpirit of wine</i>	-	316
----- <i>ſublimed</i>	-	116
----- <i>ſulphureous, of Stabl</i>	-	86
<i>Salts, definition of</i>	-	64
----- <i>effential, of vegetables</i>	-	275
----- <i>with an earthy baſis, decompoſed by volatile alkali</i>	-	339
		<i>Salt-</i>

<i>Salt-springs</i> , on	-	-	Page.261
<i>Sapphire</i> , false	-	-	254
<i>Saturnine Nitre</i>	-	-	175
<i>Saxon Blue</i>	-	-	371
<i>Scales</i>	-	-	264
<i>Schlot</i>	-	-	262, 268
<i>Sea-Salt</i>	-	-	110, 262
—— basis of	-	-	104
—— decomposed by clay	-	-	108
—— by nitrous acid	-	-	110
—— decrepitated	-	-	106
—— extracted from urine	-	-	360
—— observations on	-	-	266
—— purified	-	-	268
—— regenerated	-	-	105
—— with an earthy basis	-	-	103
<i>Sea-Water</i> , on	-	-	261
<i>Selenites</i> , calcareous	-	-	68
—— extracted from pyrites	-	-	223
<i>Semimetals</i> , what	-	-	122
<i>Silver</i> , on	-	-	129
—— extracted from lead	-	-	179
—— precipitate of	-	-	131
—— precipitated by arsenical salt	-	-	219
—— by copper	-	-	141
—— by liver of sulphur	-	-	134
—— revived from luna cornea	-	-	133
—— solution of	-	-	130
—— sulphurated	-	-	133

Silver

<i>Silver</i> tarnished by phlogiston	-	Page 134
<i>Similor</i>	-	216
<i>Soap</i> , Starkey's	-	285
— white	-	281
— decomposition of by acids	-	<i>ibid.</i>
— dissolved in spirit of wine	-	313
— lye of	-	105
<i>Soda</i> , crystals of	-	104
<i>Soot</i> , analysis of	-	343
<i>Speifs</i>	-	232
<i>Spirit of Nitre</i> , dulcified	-	308
— smoking, Glauber's	-	97
<i>Spirit of salt</i> , dulcified	-	310
— of Saturn	-	329
— of sulphur	-	85
— of Venus	-	326
— of vitriol	-	66
— of wine	-	304
— its effects on salts	-	315
— varnish	-	314
<i>Spirituos Waters</i>	-	<i>ibid.</i>
— mixed with water	-	315
<i>Spiritus Rector of Plants</i>	-	283
<i>Sponge</i> analysis of	-	365
<i>Stahl</i> , his theory of principles	-	12
<i>Steel</i>	-	164
— tempering of	-	<i>ibid.</i>
<i>Stone-Ware</i>	-	248
<i>Stras</i>	-	253
		<i>Succinated</i>

<i>Succinated Scorice of Stahl</i>	-	Page 201
<i>Suet</i> , analysis of	-	351
<i>Sulphur</i> , on	-	84
----- artificial	-	89
----- dissolved in vitriolic acid	-	87
----- flowers of	-	85, 223
----- in mineral waters	-	260
----- roll	-	224
----- separated from antimony by aqua regia	-	208
----- soft	-	85
----- spirit of	-	<i>ibid.</i>
<i>Sulphureous Salt of Stahl</i>	-	86
<i>Sympathetic Ink of Cobalt</i>	-	238

T.

<i>Tar</i>	-	294
<i>Tartar</i> , on	-	316
----- analysis of	-	317
----- cream of	-	316
----- emetic	-	320
----- soluble	-	318
----- made with absorbent earths	-	319
<i>Terra foliata tartari</i>	-	323
<i>Tincture</i> of jalap	-	312
----- of Mars	-	320
----- of metals	-	311
----- of salt of tartar	-	<i>ibid.</i>
<i>Tinctures</i> , vegetable, spirituous	-	312
<i>Tin</i> ,		

<i>Tin</i> , on	-	Page	143
----- calcined by nitre	-	-	148
----- by nitrous acid	-	-	146
----- dissolved by aqua regia	-	-	147
----- by marine acid	-	-	<i>ibid.</i>
----- by vitriolic acid	-	-	146
----- exposed to the fire	-	-	144
----- flowers of	-	-	145
----- glafs of	-	-	<i>ibid.</i>
----- leaves of	-	-	144
----- precipitates of	-	-	148
----- putty of	-	-	144
----- red calx of.	.	.	145
----- salt of	.	.	147
----- sulphurated	.	.	149
<i>Tinning of Copper</i>	.	.	<i>ibid.</i>
<i>Tombac</i>	.	.	216
----- white	.	.	219
<i>Topaz</i> , false	.	.	253
<i>Turbith Mineral</i>	.	.	183, 185
----- crystalised	.	.	184
<i>Turpentine</i> , analysis of	.	.	292
----- boiled	.	.	293

U.

<i>Urine</i> , analysis of	.	.	359
----- distillation of	.	.	360
----- extract of	.	.	361
----- fusible salt of	.	.	360, 361
			<i>Vegetable</i>

V.

<i>Vegetable Kingdom</i> , on	Page 273
<i>Verdegris</i>	325
----- crystals of	<i>ibid.</i>
<i>Vermilion</i>	192
<i>Vinegar</i> , combined with crystals of soda	324
----- with absorbent earths	<i>ibid.</i>
----- concentrated by frost	323
----- distilled	322
----- extract of	323
----- of Saturn	329
----- radical	326
<i>Vitrifiable Earths</i> , on	242
<i>Vitriol</i> , extracted from pyrites	222
----- green	153
----- calcined	<i>ibid.</i>
----- lunar	131
----- of copper	138
----- of iron and copper	160
----- of lead	175
----- of mercury	183
----- sweet earth of	155
<i>Vitriolated Tartar</i>	82, 98
----- decomposed by nitrous acid	98
----- made with liver of sulphur	90

Water,

W.

<i>Water</i> , on	Page 48
----- distillation of	51
----- different states in which it is present in salts	76
----- of Rabel	305
<i>Wax</i> , analysis of	297
----- bleaching of	298
<i>Whey</i> , analysis of	349
<i>Wine</i> , distillation of	304
----- extract of	<i>ibid.</i>
----- oil of	306
----- spirit of	304
<i>Wood</i> , analysis of	288

Z.

<i>Zaffre</i>	231
<i>Zinc</i> , on	214
----- dissolved in vitriolic acid	215
----- flowers of	214
----- purified	215

ERRATUM.

Page 71, line 22, for *alum saturated with earth* read *alum saturated with its earth*.

Printed for J. JOHNSON, No. 72,
St. Paul's Church-Yard.

Observations on the External Use of Preparations of Lead, with Remarks on Topical Applications in general, second Edition, Price 1s. 6d.

Thoughts on Hospitals, 1s. 6d.

Heads of Chemistry, 1s.

Oeconomiae Animalis Delineatio in usum Juventutis Medicæ, 1s.

Biographical Memoirs of Medicine in Great Britain, to the Time of Harvey, 4s. sewed.

A Manual of Materia Medica, containing a brief Account of all the Simples directed in the London and Edinburgh Dispensatories, with their several Preparations and the principal Compositions into which they enter, 2s. 6d. sewed.

All the above by JOHN AIKIN, M. D.

Lewis's Materia Medica, third Edit. with Additions, by J. AIKIN, M. D. 1l. 5s. boards.

